STUDIES ON THE PHENOMENA OF THE EVAPORATION OF WATER OVER LAKES AND RESERVOIRS.

By Prof. FRANK H. BIGELOW.

[Read before the Philosophical Society of Washington, D. C., March 14, 1908.]

II.—THE OBSERVATIONS ON EVAPORATION MADE AT THE RESERVOIR IN RENO, NEVADA, AUGUST 1 TO SEPTEMBER 15, 1907.[1]

The expedition to Reno, Nev., announced in the MONTHLY WEATHER REVIEW, July, 1907, to carry on some preliminary observations on the phenomena of evaporation, in preparation for the more extensive campaign at the Salton Sea, southern California, was successfully completed during the months of July, August, and September, 1907. I was accompanied by Mr. H. L. Heiskell from Washington, D. C., who assisted in the observations and the computations at Reno. We were associated with the following persons in the prosecution of the observations to whom the Weather Bureau is greatly indebted for their cooperation: Messrs. James W. Robeson, Edgar Pearson, J. F. Steffin, M. E. Jepson, Cedric Beebe, and Arthur Potthoff, as observers. Mr. H. O. Geren, local observer of the United States Weather Bureau, Prof. R. S. Minor and J. E. Church, jr., of the University of the State of Nevada, aided us in many ways, Mr. L. T. Borden, contractor, constructed the towers, and the pans were made by the Nevada Company, many other citizens of the city of Reno rendering us important services, which are cordially appreciated. The climate of Reno proved to be admirably adapted to our purposes, the air being very dry, the nights cool, and the sun hot at midday, so that the diurnal curves were very pronounced in all the meteorological elements. No showers occurred till near the end of the work, and the observations were continued day and night without interruption for six full weeks, during which time 35,000 observations, including nearly 100,000 readings of our instruments, were secured.

The Reno Reservoir is double, having a central dike running thru it on which a tower could be placed, one part supplying the city of Reno and the other part the city of Sparks with water at a considerable pressure. The water for these reservoirs is diverted from the Truckee River, which is the outlet of Lake Tahoe, 6,250 feet above sea level in the Sierra Nevada Mountains. These sierras are from 9,000 to 12,000 feet high and cut off the moist westerly winds of the Pacific Ocean, leaving the region east of the mountains very dry in the summer time, when only westerly winds prevail. At Mount Rose, on the crest of these mountains, 15 miles from Reno, about 10,500 feet high, Professor Church is maintaining an observatory, where continuous records are being secured the year round, which promises to add important data for high-level meteorology. The State University and the Agricultural Experiment Station are supplying the funds, which ought, if practicable, to be increased in order to expand the work to larger proportions.

The plain of Reno, being sheltered from the west and lying 4,000 feet above sea level, is subjected in summer to a remarkably uniform system of diurnal variations of the wind direction and velocity. In the forenoon it is calm until about 10 o'clock, when a breeze begins in the southeast and gradually swings to the westward, increasing in strength up to 30 or 40 kilometers per hour on many afternoons. We thus found the same meteorological conditions nearly repeating themselves day by day, thus including evaporation under calms and under high winds. There were enough calm afternoons occurring to enable us to separate our observations into three groups, with the winds between 1–10, 10–20, 20–40 kilometers per hour, and so to study the effect of the wind on the evaporation in an efficient manner. These local winds were caused by the drainage of cool air from the mountains down the Truckee River Valley, which extended due west from the Reno Reservoir.

Fig. 1 shows the dimensions of the double reservoirs and the location of the five towers, the line thru them running from east to west. Tower No. 1 is located in a very dry uncultivated field, and the vegetation had no influence upon the rate of evaporation. Tower No. 5 is situated in the midst of an extensive field of alfalfa, which was regularly irrigated every two weeks and kept moist enough to throw up a decided cover of vapor to the depth of several feet. A similar blanket of vapor covers the water of the reservoir, and the primary problem is to determine the rate of the evaporation from pans which are located at different points in this vapor blanket.

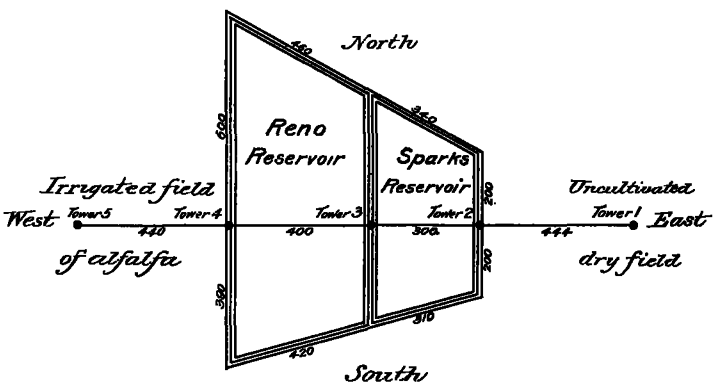

FIG. 1.—The location of five towers at the Reno Reservoir.

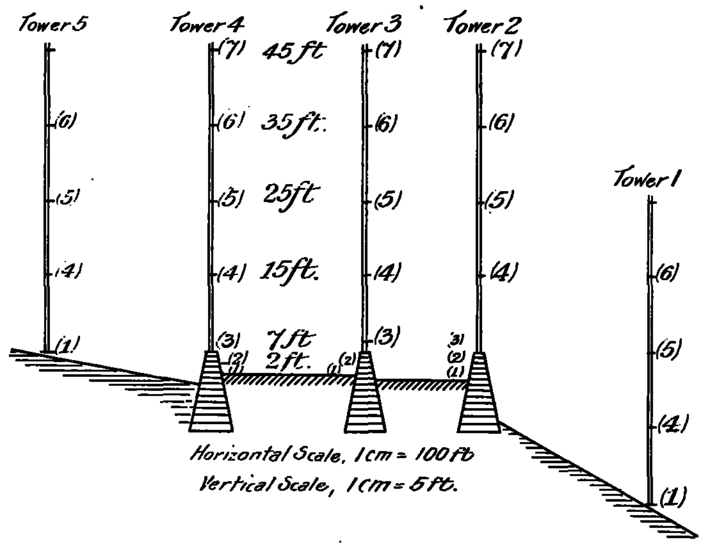

FIG. 2.—The location of the evaporation pans on the five towers.

Fig. 2 shows the location of the 29 pans which were operated during the campaign. There were 5 of the 6-foot pans, 10 inches deep, and 24 of the 2-foot pans employed; 3 of the 6-foot pans located in the water at the base of towers Nos. 2, 3, 4, and 2 of the 6-foot pans were placed on the ground at the foot of towers Nos. 1 and 5. The floating pans were surrounded by a framework of wood that stiffened them and acted as a buoy, and they were free to move within a barrier of floating breakwaters, two in succession, so that the inner spaces were freed from waves when the wind reached 20 kilometers per hour, after which there was more difficulty in keeping the spray out and the waves from surging under the breakwaters. It is not possible to float large pans in a lake which is subject to long waves and high winds, and at the Salton Sea no attempt will be made to float the pans. Instead

[1] For paper No. I see Monthly Weather Review, July, 1907, Vol. XXXV, p. 311–316.

of this method, the pans will be suspended near the water and raised or lowered according to the weather conditions. The small 2-foot pans were, also, 10 inches deep, and they were placed on platforms extending over the south side of the towers, so that the sun was free to shine upon them from morning till night. There were three intentional exceptions made in the location of the pans. On tower No. 3 pan 3 was placed against the outside of the lower section, which was boarded in and served as an office room, so that it received an excess of heat during the day; pans 4 and 5, on the contrary, were placed on the north side of their platforms so that they were shaded by the upper platforms from 9 a. m. till 3 p. m., and contrasted with pan 3, by receiving a smaller amount of heat. The effect was to raise the vapor pressure in pan 3 and lower it in pans 4 and 5, relatively to the other pans on the same towers. There was, however, very little effect on the rate of the evaporation from these pans. The pans 7 on the top of towers Nos. 1 and 5 were not put in place, because their record would be almost identical with that of pans 6 on these towers. The pans on towers Nos. 2, 3, 4, and 5 were very nearly on the same levels.

Pan No. 7 at 45 feet.	Pan No. 3 at 7 feet.
Pan No. 6 at 35 feet.	Pan No. 2 at 2 feet.
Pan No. 5 at 25 feet.	Pan No. 1 at 0 feet.
Pan No. 4 at 15 feet.	

The tower No. 1 was located on ground which was about 20 feet lower than the bank of the reservoir. The nature of the soil was such that the record for the evaporation would have been the same if it had been raised to the common level of the other towers. The pans 1, 2, and 3 of tower No. 2 were reached by a bridge 20 feet long leading to the crib, and they were well surrounded by the waters of the reservoir on all sides. The pans 1 and 2, of towers Nos. 3 and 4 were reached by platforms extending into the lake from the shore, to which they were lashed, and they rose and fell as the waters of the reservoir changed their levels from day to day, the range being thru several feet during the summer.

Fig. 3 shows tower No. 2, with some pans on the ground. The lower section was boarded and sheathed against the weather, and it was occupied day and night by the observer, Mr. J. W. Robeson, to whose faithful and efficient services much of the success of this work is due. The lower section of tower No. 3 was used as an office, and that of tower No. 4 as a camp for other observers who were on duty during the night.

Fig. 4 gives a general view of the five towers looking eastward from No. 5 in the alfalfa field, and fig. 5 shows towers Nos. 2 and 3, and a portion of the western reservior which feeds the city of Reno, and especially the dike which enabled us to place a tower in the middle of the lake. The pans can be seen on the towers in the positions that have been desscrbed. Fig. 5 (*a*, *b*, *c*, *d*) give further details regarding the lower pans.

THE METHOD OF TAKING THE OBSERVATIONS.

The purpose for which the observations were planned was to discover, if possible, the immediate cause of the discrepancies which exist between the results of several excellent researches on the rate of evaporation in the open. These may be attributed to the adopted formulas, or to an actual difference in the rate of evaporation near the same body of water, as determined by the action of the vapor blanket which covers every lake. If large numbers of pans are placed at different points in this vapor cloud, and if they are precisely alike themselves, the method of observing being always uniform, then any difference in the observed rate at the different pans must be primarily a physical phenomenon to study, with the object of deriving a comprehensive general formula. The metric system of measurements were used thruout, because of its superior advantages in the discussion of thermodynamic problems. An ordinary sling psychrometer, carrying wet and dry-bulb thermometers, was used to find the temperature and the dew-point of the air near the pans. A small raft was made, sustaining a water thermometer on the lower side, which was *just submerged beneath the surface of the water*, and on the upper side wet and dry-bulb thermometers floated about *one-half an inch above the water surface*. These instruments enabled us to obtain *the temperature and the vapor pressure, (1) at the surface of the water, (2) at a plane one-half an inch above the water surface, and (3) in the free air that was blowing over the pans.*

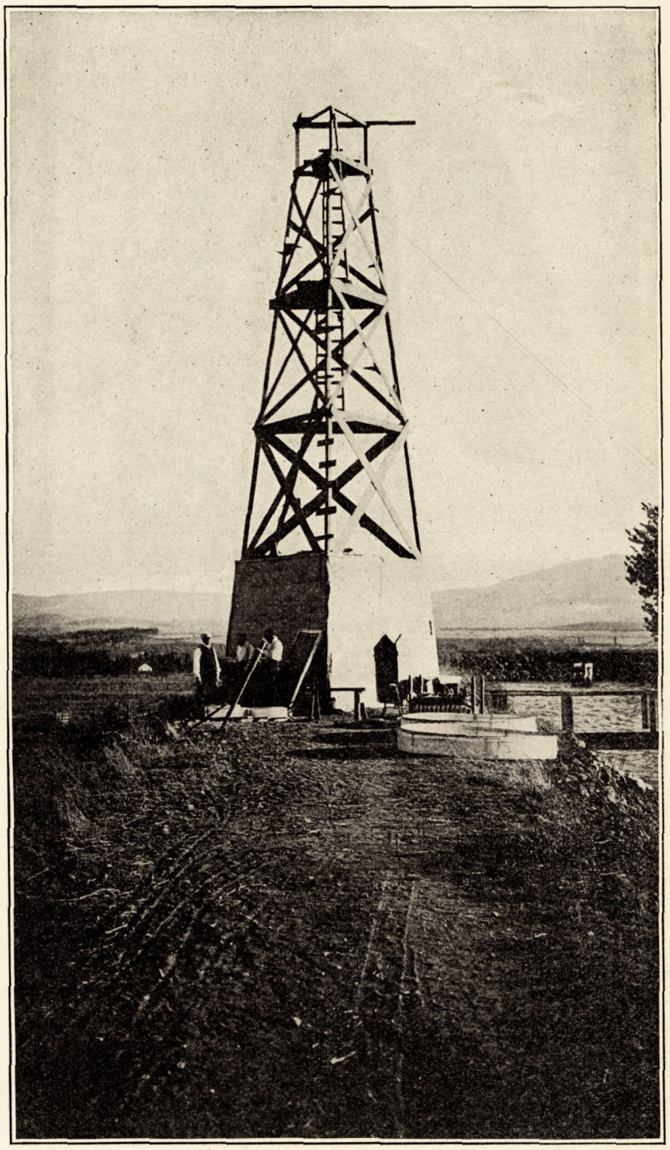

FIG. 3.—Tower No. 2, on the east bank of the reservoir, showing the landings for four pans, two of the 6-foot pans and several 2-foot pans on the ground near the tower. The towers are 40 feet high, built in a prism and guyed down with wire cables to withstand gusts of wind, as much as 40 miles per hour. The mountains on the right, looking south, include Mount Rose, about 16 miles distant.

To measure the depth of the water in the pans, the surface of which is always ruffled by the wind, we employed a glass tube graduated to cubic centimeters, the scale being nearly in millimeters, and the tube being drawn to a narrow neck at the bottom. A plunger consisting of a plug on a copper wire was fitted to move up and down with the finger as desired, which on being prest down shut off all communication thru the bottom. Raising this to the level of the eye the top of

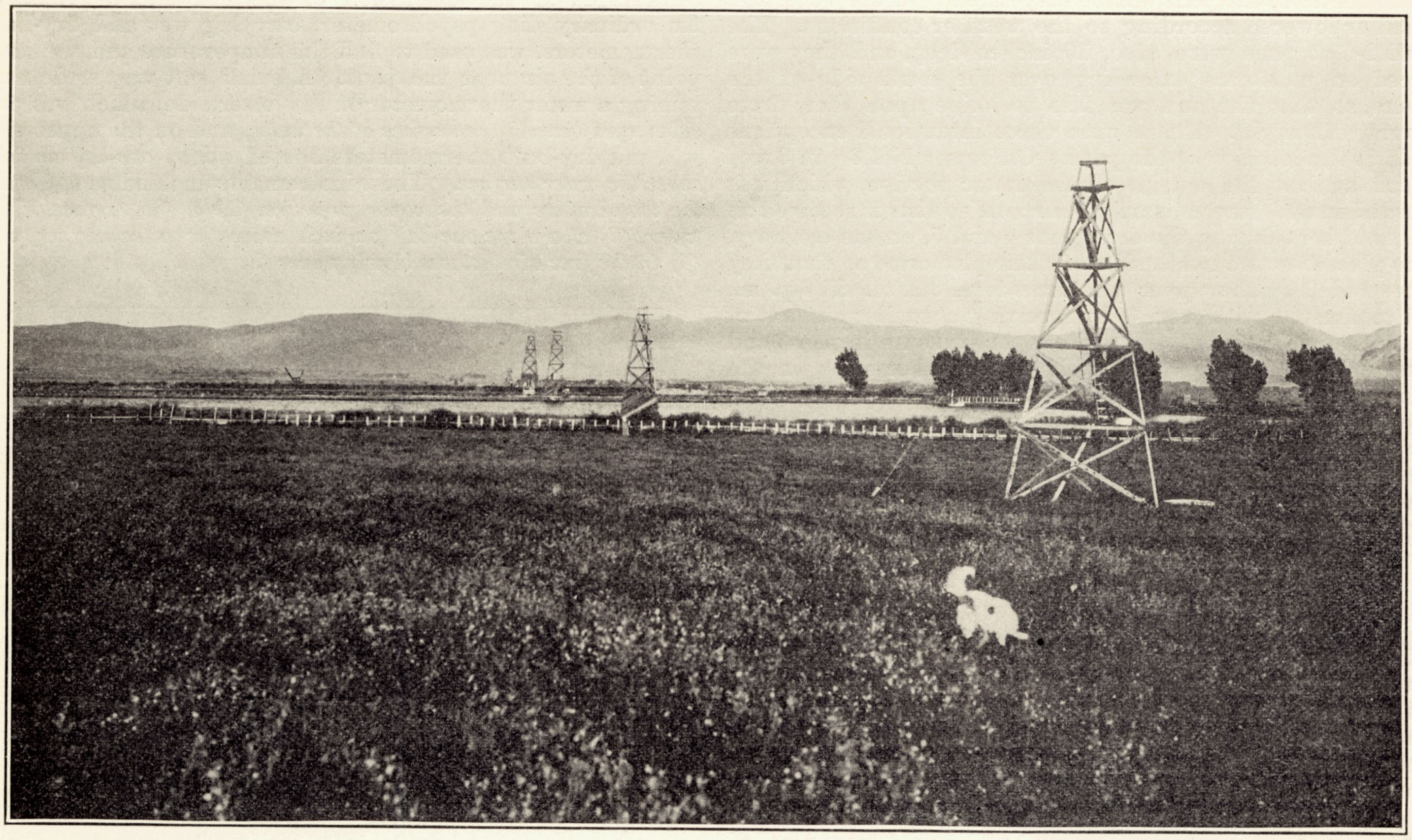

FIG. 4.—The location of the five towers for the evaporation pans. The distant tower is No. 1 to the east and the nearest is No. 5 to the west.

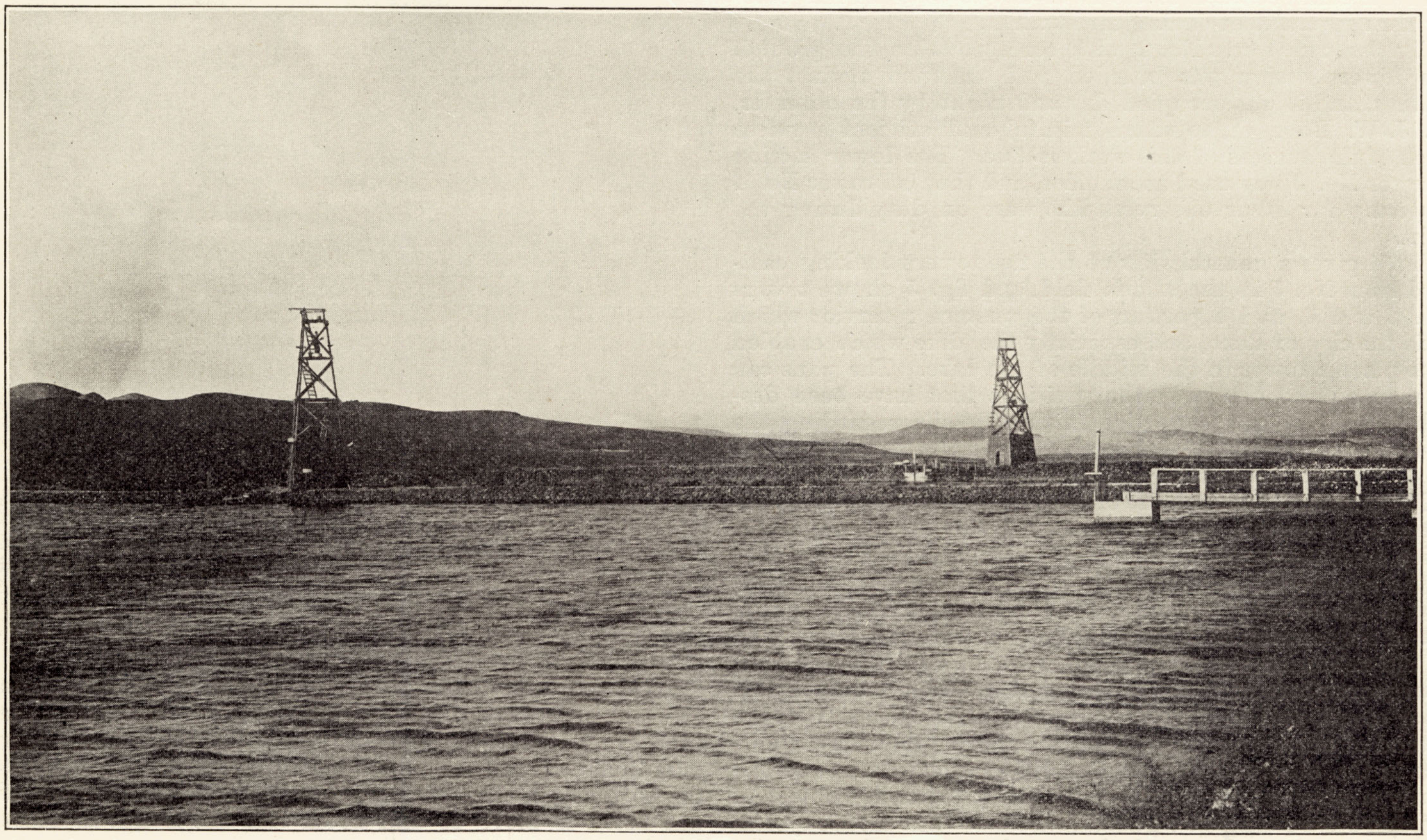

FIG. 5.—A portion of the Reno Reservoir, showing the central tower No. 3 and the tower No. 2. The crib at No. 2 was used to work three pans.

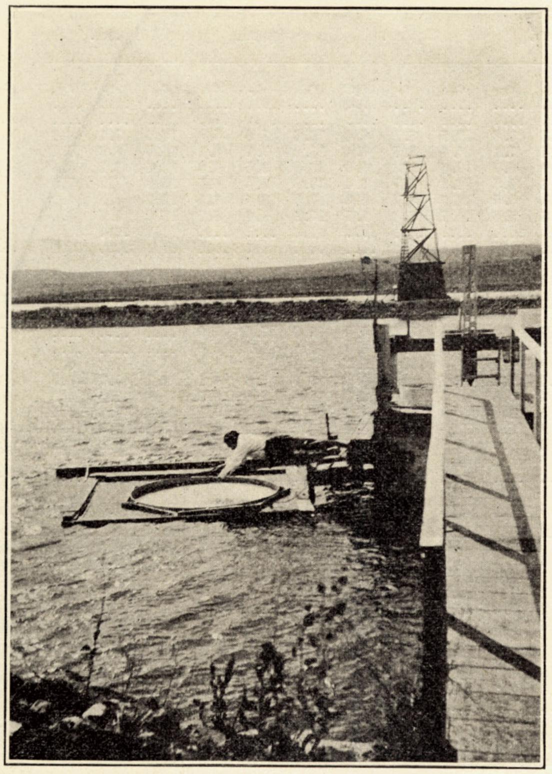

FIG. 5 *a*.—Pans at tower No. 2.

FIG. 5 *c*.—Pans at tower No. 1.

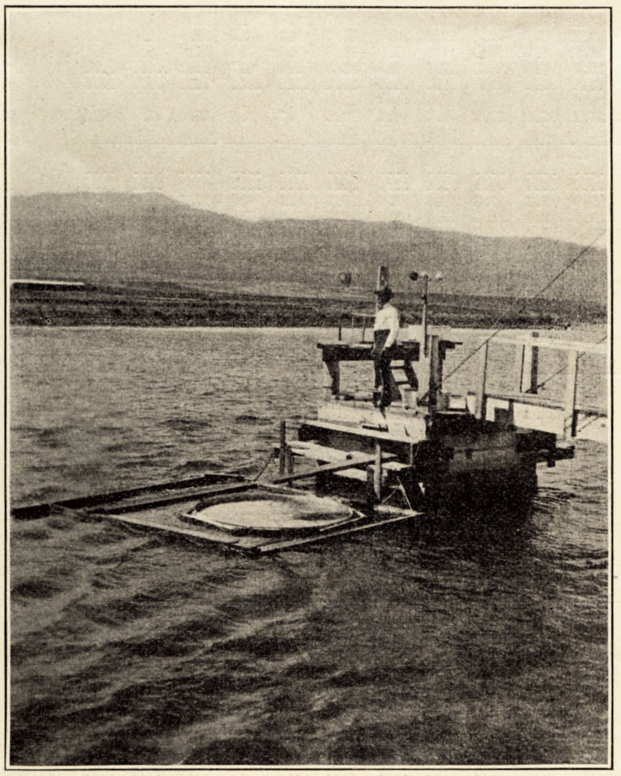

FIG. 5 *b*.—Pans at tower No. 2.

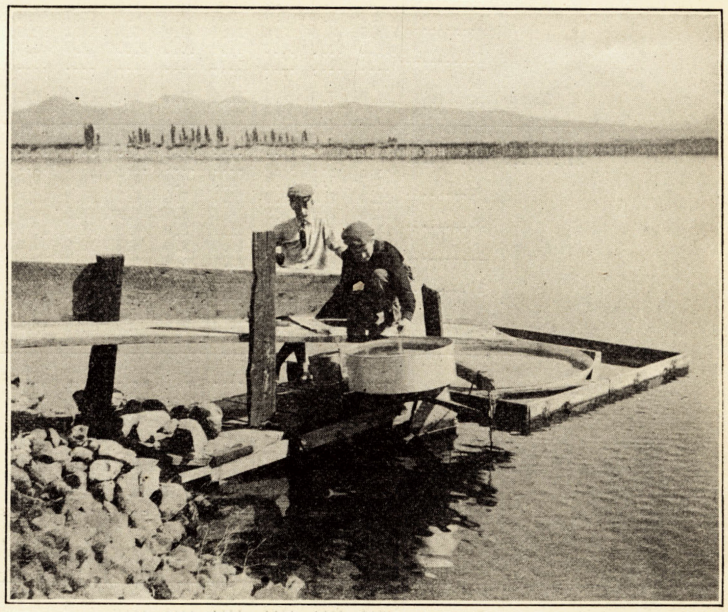

FIG. 5 *d*.—Pans at tower No. 4.

the meniscus of water was easily read off to a fraction of a millimeter on the vertical scale. No account was taken of the volume, but the scale was read from time to time at the same point in each pan, and the difference of height between readings measured the amount lost by the evaporation. The readings were finally reduced to millimeters by a proper scale-factor, and the difference of readings for a given interval, as three hours, is a measure of the amount evaporated in the pan. The sling psychrometer, the raft with the three attached thermometers, the vertical scale tube, and a dish of water for wetting the rag on the sling psychrometer, were placed in a basket and carried from pan to pan on the same tower, so that we are now dealing in our final results with strictly differential values, there being thus no question of corrections to the absolute readings of the instruments.

TABLE 5.—*Reno Reservoir. Diurnal variation of the vapor pressure. August 1-10, 12-17, 1907.*

Pan.	Tower.	1 a.m.			5 a.m.			8 a.m.			11 a.m.			2 p.m.			5 p.m.			8 p.m.		
		e_s	e_r	e_d	e_s	e_r	e_d	e_s	e_r	e_d	e_s	e_r	e_d	e_s	e_r	e_d	e_s	e_r	e_d	e_s	e_r	e_d
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	4	11.3	8.2	6.6	10.0	6.9	6.2	14.3	8.8	6.8	21.2	9.3	6.8	19.5	8.1	6.4	16.6	7.6	5.8	14.6	7.1	6.1
		11.8	8.3	6.3	11.0	9.4	6.5	16.6	11.8	7.3	24.5	11.4	7.1	24.4	8.7	6.4	18.2	7.1	6.1	14.0	8.3	5.7
	3	12.4	9.0	7.2	10.5	8.5	6.5	15.6	10.1	6.8	20.7	9.0	6.7	19.6	9.3	6.0	16.8	8.5	6.3	12.6	7.2	5.8
		13.0	7.4	4.7	10.7	7.8	5.5	15.0	11.9	7.7	21.8	11.3	7.5	24.9	9.5	6.4	19.8	8.3	6.5	15.0	7.2	5.9
	2	12.3	8.0	6.3	10.0	8.1	6.8	15.1	9.9	6.9	18.8	10.1	6.5	18.9	8.7	6.3	16.0	8.4	6.1	18.2	8.2	6.9
		9.8	8.0	5.6	10.4	7.9	6.3	15.5	11.5	6.9	22.4	10.5	5.8	24.7	8.8	7.7	17.9	8.6	6.0	16.0	8.7	5.5
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Means		11.8	8.2	6.1	10.4	8.1	6.2	15.4	10.7	7.1	21.6	10.3	6.7	22.0	8.9	6.5	17.6	8.1	6.1	14.2	7.8	6.0
6	5	....	....	....	....	....	....	13.2	7.1	8.5	19.5	9.7	6.3	17.2	8.1	5.0	15.0	7.4	5.0	....	....	....
		....	....	....	....	....	....	18.1	11.8	7.6	23.9	11.7	8.6	23.8	9.6	6.3	17.9	7.9	5.8	....	....	....
	4	11.5	7.9	6.0	10.2	7.1	6.4	14.5	9.0	6.9	22.9	9.9	6.9	20.5	8.8	6.3	17.3	7.9	6.0	15.2	7.2	6.1
		11.8	8.9	6.6	10.7	8.5	6.3	16.1	11.9	7.9	24.1	12.1	7.2	25.7	8.8	6.5	18.9	7.6	6.1	14.1	7.7	5.7
	3	12.3	9.3	7.0	10.2	7.5	6.5	15.0	10.9	7.2	20.3	9.8	6.6	19.5	8.8	6.3	16.6	8.0	6.1	12.9	7.5	5.8
		13.0	7.1	4.8	10.8	7.7	5.6	14.2	10.1	7.6	21.7	10.5	7.9	24.9	9.4	6.5	19.7	7.0	6.1	14.8	7.3	5.5
	2	12.3	8.2	6.5	9.8	8.0	6.2	14.5	9.7	6.9	18.9	9.9	6.5	19.3	8.3	6.4	16.2	8.1	6.3	12.4	7.9	6.0
		9.8	8.8	5.7	10.2	7.5	6.3	14.8	11.4	7.2	22.2	11.0	6.0	24.9	9.6	6.7	18.2	8.6	5.8	16.4	9.0	5.5
	1	....	....	....	....	....	....	12.8	10.0	7.5	20.1	10.7	6.2	24.4	9.8	6.5	20.8	8.5	6.0	....	....	....
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Means		11.7	8.3	6.1	10.2	7.7	6.2	14.9	10.2	6.9	21.5	10.5	6.8	22.2	9.0	6.8	17.8	7.9	5.9	14.8	7.8	5.8
5	5	....	....	....	....	....	....	13.3	7.5	5.7	19.5	9.5	6.3	18.0	7.5	5.1	16.0	7.8	5.4	....	....	....
		....	....	....	....	....	....	17.6	11.4	7.9	23.6	12.1	8.0	24.3	8.7	7.0	18.0	7.4	6.8	....	....	....
	4	11.2	7.7	6.6	9.6	6.9	6.4	13.8	9.6	6.9	22.6	10.2	7.8	20.8	9.2	6.4	17.8	8.5	6.0	15.3	7.8	6.2
		11.8	8.0	6.8	10.6	8.2	7.0	15.3	10.8	7.7	23.6	12.2	7.8	26.0	10.5	6.6	18.9	7.9	6.2	14.2	7.5	5.9
	3	12.2	7.8	7.2	10.3	8.3	6.4	13.3	9.7	7.1	15.2	7.6	6.6	18.1	9.4	6.3	17.0	9.0	6.0	13.3	7.6	5.9
		12.7	5.5	5.2	10.5	8.1	5.9	13.2	9.8	6.1	16.7	8.2	6.9	21.8	8.9	7.5	19.7	9.0	6.2	15.1	7.6	5.9
	2	12.3	7.2	7.2	9.8	7.9	6.2	14.3	10.0	7.2	18.4	10.1	6.4	19.6	8.7	6.5	16.5	8.0	6.2	13.3	7.5	5.7
		9.8	7.8	5.9	10.2	7.8	5.4	14.6	12.0	7.1	22.0	10.5	6.1	25.5	9.1	6.7	18.8	8.9	6.3	16.8	8.2	5.7
	1	....	....	....	....	....	....	12.9	9.7	7.3	19.6	10.0	6.2	24.9	9.5	6.8	21.6	9.2	5.7	....	....	....
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Means		11.7	7.3	6.5	10.2	7.8	6.2	14.3	10.1	7.0	20.1	10.0	6.8	22.1	9.1	6.5	18.3	9.4	6.1	14.7	7.7	5.9
4	5	....	....	....	....	....	....	13.1	7.6	6.1	19.5	10.0	7.0	18.8	7.9	5.4	16.6	8.1	6.5	....	....	....
		....	....	....	....	....	....	17.3	12.0	8.4	23.6	12.6	9.0	25.3	9.9	7.1	18.8	7.4	6.1	....	....	....
	4	11.2	8.0	7.2	9.4	7.2	6.4	13.8	9.0	7.2	23.2	10.1	7.6	22.3	9.0	6.8	19.2	9.0	6.5	16.2	7.8	5.8
		11.5	7.2	6.9	10.5	7.9	6.6	14.8	11.8	8.2	23.7	12.6	7.5	27.3	9.9	7.1	19.5	8.2	6.4	14.7	7.2	5.9
	3	12.7	8.2	7.4	10.4	8.6	6.5	14.1	9.8	8.0	16.1	7.6	6.7	18.8	9.5	6.2	18.1	8.9	6.4	14.1	7.9	6.3
		13.3	7.5	6.8	10.5	8.0	6.2	12.6	9.9	7.3	16.0	8.5	7.3	23.1	8.9	8.0	20.7	8.7	7.0	16.0	7.5	6.3
	2	12.3	8.0	7.0	9.8	7.8	6.5	13.7	10.4	7.2	18.2	9.2	6.7	20.7	9.2	6.7	17.6	9.1	6.5	13.9	8.0	6.0
		10.5	8.4	5.8	10.1	7.9	6.3	14.2	12.0	7.1	21.7	10.9	6.3	26.6	9.8	7.0	19.4	9.4	6.8	17.7	8.7	6.1
	1	....	....	....	....	....	....	12.3	9.3	7.4	19.5	10.7	6.0	26.2	10.6	6.8	22.8	9.8	6.7	....	....	....
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Means		11.9	7.9	6.7	10.1	7.9	6.4	14.0	9.1	7.6	20.2	10.2	7.1	23.2	9.4	6.7	19.2	8.7	6.5	15.4	7.8	6.1
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	4	11.7	7.7	7.5	9.9	7.8	6.7	12.8	9.0	7.9	19.4	9.0	9.1	19.8	8.6	7.6	20.1	9.9	6.9	16.7	7.6	5.9
		12.2	7.6	6.9	10.7	7.6	6.7	11.4	10.0	9.1	21.9	9.8	9.1	21.3	10.4	8.5	20.5	7.8	7.5	15.4	7.1	5.9
	3	13.0	8.2	8.2	10.5	8.8	6.9	15.2	11.0	7.6	19.7	10.5	7.5	23.8	11.5	7.1	19.6	9.6	6.9	14.6	8.8	7.2
		15.2	9.3	6.8	11.1	8.0	6.5	14.0	10.9	7.4	22.7	12.6	8.2	29.8	11.9	9.3	23.8	9.6	8.1	17.6	8.5	6.7
	2	12.8	9.4	7.7	10.0	7.9	6.4	13.9	9.6	7.3	17.8	9.5	6.9	21.2	9.4	6.5	18.1	8.8	6.8	14.2	8.6	6.4
		10.4	8.8	6.1	10.1	7.8	5.9	12.7	10.8	7.1	20.2	9.8	6.2	25.5	9.9	7.9	20.2	10.0	6.9	16.8	9.1	6.4
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Means		12.5	8.5	7.2	10.4	7.9	6.5	13.3	10.2	7.7	20.3	10.2	7.8	23.5	10.3	7.8	20.4	9.3	7.2	15.9	8.3	6.4
2	5	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	4	11.9	8.7	8.2	11.1	7.5	7.1	14.0	9.5	7.6	22.5	11.0	8.6	23.3	9.9	7.2	21.8	11.0	7.3	17.6	8.7	6.0
		12.6	8.8	7.3	11.2	8.7	7.4	14.9	12.9	8.2	22.8	13.6	7.6	25.6	11.4	7.9	23.6	10.0	7.8	16.6	8.1	6.5
	3	13.4	8.9	8.1	10.6	7.9	7.0	12.6	9.1	7.6	18.4	11.3	7.9	23.3	13.0	7.2	22.1	10.3	7.5	17.2	8.6	6.6
		14.5	7.7	7.7	10.8	7.9	6.7	10.8	8.9	7.8	19.8	10.7	8.4	26.4	12.4	9.0	24.8	10.6	8.3	18.0	8.5	7.3
	2	13.1	9.5	7.4	10.1	8.2	6.8	12.7	10.2	7.5	17.1	10.7	7.2	21.5	10.0	7.5	18.3	9.4	7.1	14.5	9.2	6.5
		10.6	8.7	6.8	10.3	8.8	6.1	12.8	11.3	7.7	19.0	10.3	6.7	25.5	9.4	7.8	19.9	9.8	7.3	16.7	8.4	6.6
	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Means		12.7	8.6	7.6	10.7	8.1	6.9	13.0	10.3	7.7	19.9	11.3	7.7	24.3	12.7	7.8	21.8	10.2	7.6	16.8	8.6	6.6
1	5	....	....	....	....	....	....	12.6	8.1	7.0	20.4	10.7	8.3	21.3	9.7	6.8	18.6	9.3	6.5	....	....	....
		....	....	....	....	....	....	16.2	12.5	9.7	22.2	15.7	9.8	26.5	11.5	8.6	20.8	8.7	6.9	....	....	....
	4	15.6	9.4	8.5	14.1	8.3	7.1	16.1	11.1	9.4	20.3	12.1	9.8	18.9	10.5	8.1	16.9	10.3	7.5	15.2	10.1	6.3
		13.9	10.4	8.1	15.3	9.5	7.6	16.4	12.1	8.6	20.9	12.9	8.5	20.0	12.5	8.4	18.1	10.8	8.1	14.4	8.3	6.9
	3	15.3	11.0	8.6	15.0	8.7	7.4	15.9	10.4	8.1	19.1	11.4	8.6	19.0	14.6	7.9	17.9	13.4	8.4	15.4	9.3	7.1
		15.4	11.0	11.0	14.2	9.6	7.5	14.5	9.7	8.0	18.2	12.2	8.4	21.7	14.3	9.4	18.4	11.8	8.7	15.0	10.2	7.8
	2	14.4	9.5	8.8	13.9	9.9	6.8	15.8	11.2	7.6	18.4	11.4	7.9	18.3	10.8	7.4	16.3	10.1	7.8	13.7	10.5	6.6
		11.6	9.0	7.8	13.3	9.3	7.3	15.9	12.0	8.1	19.8	12.1	7.5	19.9	11.1	8.0	17.2	12.2	7.6	15.0	9.7	6.9
	1	....	....	....	....	....	....	11.9	8.0	7.5	17.6	11.1	7.6	26.4	11.1	6.9	24.2	10.0	7.4	....	....	....
		....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Means		14.4	10.1	8.8	14.3	9.2	7.3	15.0	10.6	8.2	19.7	12.2	8.5	21.3	11.8	7.9	18.7	10.7	7.7	14.8	9.7	6.9

The unit = 1 millimeter of mercury.

The centigrade thermometers were kindly loaned to the expedition by Prof. R. S. Minor, Physicist of the University of Nevada, and the tubes were purchased in Reno. The anemometers were furnished by the Instrument Division of the Weather Bureau, having been adapted by Prof. C. F. Marvin to read in kilometers per hour. One anemometer was read continuously thruout the interval August 1 to September 14, and a special series of readings were taken with 13 anemometers by Mr. Robeson from September 21 to October 6, inclusive, at 8 and 11 a. m., and 2 and 5 p. m. These anemometers were distributed at the bottom and top of the towers Nos. 1, 4, and 5, while No. 3 had three instruments and No. 2 had four instruments. The differential action from the bottom to the top of the towers was thus reduced to a simple formula, which will be discust in the following paper of this series. The hours of observation were as nearly as possible 1, 5, 8, and 11 a. m., 2, 5, and 8 p. m. for all the towers, except that at 1 a. m. the towers Nos. 1 and 5 were omitted and on tower No. 2 the readings were made Monday and Thursday nights, on tower No. 3 Tuesday and Friday nights, and on tower No. No. 4 Wednesday and Saturday nights. The pans were filled about 10 o'clock every forenoon. The order of the readings at each tower was kept identical, so that the time elapsed was not very different from day to day, a record being made of the hour and minute of beginning and ending at each tower. It took from 40 to 70 minutes to read all the instruments at the seven pans on each of the middle towers, Nos. 2, 3, and 4, according to circumstances, and in nearly all cases the thermometers were read three times at each pan, as well as the tube for height, in order to insure accurate mean values. The labor of climbing the towers seven times daily and making the observations in the wind, which at times was more than 40 kilometers per hour, was not inconsiderable, and the observers are entitled to much praise for their patience and fidelity in executing this routine. No personal accidents occurred to the observers, tho several thermometers were broken during the summer. The result is that we now possess a large number of strictly differential values of the evaporation in the midst of meteorological conditions which characterize the lower layers of air and vapor, as they are superposed upon a body of water evaporating in a very dry climate where the wind factor is also very conspicuous.

THE TABLES OF VAPOR PRESSURE AND EVAPORATION AT THE RENO RESERVOIR AUGUST 1–10, 12–17, 1907.

The weekly summaries of the values of the vapor pressure and the evaporation are found in Tables 5 and 6. They are arranged to show these data for each pan on each tower for each week separately and for the seven hours of observation. From the dry-bulb temperature t and the wet-bulb temperature t_1 the vapor pressure was found by a special table, computed for the elevation of Reno, where the average barometric pressure is $B=645$ mm., using the formula,

$$e=e_0-0.00066\,B\,(t-t_1)\left(1+\frac{t_1}{873}\right). \tag{27}$$

This formula differs somewhat from the one commonly found in psychrometric tables, where the full formula is slighly modified for the sake of convenience in computing. With the arguments t_1 (wet) and $t-t_1$ (dry-wet) the vapor pressure e is taken out. This table serves for the sling psychrometer and the floating psychrometer on the small raft. The vapor pressure of saturation at the temperature of the water gives a third value of the vapor pressure. As arranged on Table 5, there is found under each hour the mean weekly value of these three vapor pressures:

e_s=the vapor pressure at the temperature of the water;
e_r=the vapor pressure of the air one-half an inch above the water;
e_d=the vapor pressure of the air at the dewpoint temperature.

TABLE 6.—*Reno Reservoir. Diurnal variation of the evaporation. August 1–10, 12–17, 1907.*

Pan.	Tower.	8 p.m. to 1 a.m.	1 a.m. to 5 a.m.	5 a.m. to 8 a.m.	8 a.m. to 11 a.m.	11 a.m. to 2 p.m.	2 p.m. to 5 p.m.	5 p.m. to 8 p.m.	Total.
7	5	.....	.....	.....	.....	.....	.....	.....	.....
		.....	.....	.....	.....	.....	.....	.....	.....
	4	.207	.248	.190	.273	.395	.375	.295	1.983
		.159	.147	.204	.249	.388	.475	.393	2.015
	3	.259	.225	.161	.170	.413	.388	.328	1.944
		.173	.130	.176	.207	.388	.832	.303	1.709
	2	.197	.189	.189	.293	.513	.440	.251	2.072
		.132	.130	.203	.331	.516	.437	.234	1.983
	1	.....	.....	.....	.....	.....	.....	.....	.....
Means		.188	.178	.187	.253	.435	.407	.300	1.951
6	5	.176	.193	.194	.294	.397	.293	.155	1.702
		.139	.128	.184	.207	.356	.278	.217	1.509
	4	.215	.228	.181	.217	.449	.264	.284	1.838
		.145	.137	.184	.261	.346	.337	.337	1.747
	3	.265	.251	.170	.202	.367	.345	.228	1.828
		.173	.158	.130	.176	.488	.400	.383	1.908
	2	.200	.167	.189	.259	.533	.471	.228	2.047
		.121	.107	.234	.331	.502	.406	.282	1.983
	1	.099	.082	.141	.312	.464	.446	.234	1.778
Means		.169	.161	.178	.251	.433	.360	.261	1.811
5	5	.155	.194	.172	.258	.379	.259	.155	1.572
		.145	.155	.207	.161	.346	.371	.195	1.580
	4	.190	.176	.139	.207	.288	.253	.230	1.483
		.118	.112	.149	.116	.346	.311	.379	1.531
	3	.251	.236	.150	.256	.328	.340	.228	1.784
		.161	.144	.130	.193	.325	.449	.325	1.727
	2	.175	.171	.197	.240	.460	.491	.262	1.996
		.121	.119	.267	.361	.502	.392	.172	1.934
	1	.085	.088	.127	.366	.446	.375	.212	1.699
Means		.155	.155	.159	.240	.379	.360	.239	1.701
4	5	.145	.182	.190	.226	.362	.207	.139	1.451
		.139	.155	.149	.184	.311	.333	.207	1.478
	4	.166	.166	.126	.221	.242	.275	.230	1.396
		.124	.112	.104	.058	.242	.265	.379	1.284
	3	.202	.172	.127	.170	.382	.395	.167	1.615
		.127	.058	.112	.130	.293	.351	.403	1.474
	2	.164	.155	.252	.259	.298	.406	.197	1.731
		.113	.129	.220	.330	.423	.375	.220	1.810
	1	.079	.096	.093	.141	.541	.375	.175	1.500
Means		.139	.136	.152	.191	.343	.331	.235	1.526
3	5	.....	.....	.....	.....	.....	.....	.....	.....
		.....	.....	.....	.....	.....	.....	.....	.....
	4	.162	.221	.161	.177	.265	.242	.207	1.435
		.189	.134	.116	.158	.219	.265	.311	1.392
	3	.173	.135	.118	.213	.360	.288	.258	1.545
		.070	.101	.161	.225	.271	.320	.266	1.414
	2	.133	.149	.220	.197	.282	.293	.209	1.483
		.104	.119	.189	.299	.384	.344	.141	1.580
	1	.....	.....	.....	.....	.....	.....	.....	.....
Means		.138	.143	.160	.211	.296	.292	.236	1.475
2	5	.....	.....	.....	.....	.....	.....	.....	.....
		.....	.....	.....	.....	.....	.....	.....	.....
	4	.124	.104	.116	.207	.288	.127	.239	1.205
		.083	.060	.079	.158	.216	.175	.245	1.016
	3	.181	.204	.115	.150	.270	.165	.172	1.257
		.058	.086	.112	.193	.144	.239	.188	1.020
	2	.149	.133	.120	.124	.298	.224	.182	1.230
		.113	.141	.103	.234	.230	.251	.169	1.241
	1	.....	.....	.....	.....	.....	.....	.....	.....
Means		.118	.121	.108	.178	.241	.197	.198	1.162
1	5	.114	.104	.139	.207	.311	.172	.139	1.286
		.124	.104	.161	.139	.149	.288	.139	1.104
	4	.091	.031	.126	.188	.159	.139	.139	0.873
		.071	.068	.126	.080	.126	.184	.116	0.771
	3	.040	.055	.058	.127	.144	.193	.060	0.677
		.092	.072	.176	.172	.176	.127	.130	0.945
	2	.136	.116	.175	.200	.324	.382	.234	1.467
		.093	.119	.214	.220	.299	.234	.172	1.351
	1	.093	.062	.152	.200	.475	.371	.223	1.476
Means		.095	.081	.137	.170	.240	.221	.150	1.115

The unit = 1.000 centimeters in height.

On tower No. 1 the readings for the first week were not secured because it was not finished. The pans on towers Nos. 5 and 1 were not read during the night, but they would show very little difference from those on the other towers during the nighttime, when the air was cool. We possess similar tables of the vapor pressure and the evaporation for the other four weeks, as well as the corresponding temperature tables, but those which are here presented illustrate sufficiently their general appearance, and from them the main features of the phenomenon can be readily learned. The original tables which give the results day by day show how steady the climate of Reno is during the summer months, and how favorable the conditions were for bringing to light the subtle physical conditions under which the evaporation takes place, and to which it responds with remarkable sensitiveness. We are concerned in this paper simply with the action of the evaporation at the several towers and at different heights above the water. In the following paper of this series we shall discuss the diurnal variation and the formula which seems to be competent to eliminate the diurnal changes of rate of the evaporation.

Table 5 is transferred to figs. 6–12, where the characteristics of the vapor pressure are shown every three hours on six pans at the five towers. On figs. 9 and 10, at tower No. 3, pan 3, will be noted the excess of e_s, due to an overheating of the water in the pans, and at pans 4 and 5 a defect due to shading the pans, as stated above. The vapor pressure at the surface of the water e_s ranges thru wide limits, 12 to 24 mm., while the vapor pressure of the air very near the water e_r and in the air somewhat free from the water ranges very little during the day, e_r changing between 7 and 12 mm., while the vapor pressure of the air e_d ranges from 6 to 9 mm. The courses of e_r and e_d are nearly parallel thruout the day at all the towers, the spaces widening somewhat in the heat of the day as compared with the night. Table 6 is transferred to figs. 13–20, where the characteristics of the evaporation are shown from hour to hour at the seven pans on each tower. It was necessary to interpolate values on towers Nos. 1 and 5 at the pans 2, 3, and 7, but it is evident that this can properly be done under the circumstances. The increase of the evaporation from 5 a. m. to 2 p. m. is strikingly illustrated, and also the facts that the evaporation is less in the middle of the lake than at the side towers, also less than in the upper pans. The lower pan of tower No. 5 in the moist alfalfa field is less than at tower No. 1 in the dry field, so that the irrigated field partakes of the nature of an imperfect water surface. A study of these tables and diagrams and the evident necessary inferences are very interesting. *They show clearly that the location of the pans relative to the water of a reservoir is of primary importance in measuring the total amount of evaporation, and that observations on a pan away from the water can not be transferred to the water surface itself except with the utmost caution.*

III.—DISCUSSION OF THE OBSERVATIONS MADE AT RENO, NEV., AUGUST 1 TO SEPTEMBER 15, 1907.

THE METEOROLOGICAL DATA.

The observations on the five towers erected at the Reno Reservoir afford an unusual opportunity to study the variations of the temperatures of the water, the air above the water, the vapor pressures, the wind velocities, and the evaporation, as functions of the height up to about 50 feet. These are valuable for meteorologists generally because they have an application to the questions of the exposures of the instruments at different levels. No attempts were made to use shelters of any sort, the psychrometers being swung vigorously in the free air, the motion being sufficient to eliminate the direct solar radiation, as was found by some comparative experiments. The thermometers on the raft were so close to the water surface as to be controlled by it, one being submerged, another being attached by a moistened rag hanging in the water, and the dry thermometer lying in the vapor of the evaporating water, from which there is no reflected heat. In discussing the subject of evaporation it is of first importance to separate out the effect of the wind velocity, and next it is necessary to find a function that will eliminate the diurnal variation, there being left a third function which depends upon diffusion in a quiet atmosphere at a given temperature. In order to measure the wind velocity the ordinary Robinson anemometers of the Weather Bureau pattern, reading on the dials in miles per hour, were transformed by a device of Prof. C. F. Marvin to read in kilometers per hour on the same dials. During the time which elapsed before these instruments were delivered a standard anemometer in miles per hour was read near the bottom of tower No. 2, at pan 3, thruout the observations. Afterwards the twelve new anemometers in kilometers per hour were added and distributed up and down the towers, two on No. 1, three on No. 2, three on No. 3, two on No. 4, two on No. 5, besides the English anemometer. During the interval of these special wind observations the number of those at the high velocities was not very great, but the evidence from the three anemometers on each of towers Nos. 2 and 3 is that a straight line, inclined at different angles, may be used to connect the velocity at the bottom with the velocity at the top of the tower. The result of the discussion is shown on figs. 21 and 22. A given wind velocity at the bottom is accompanied on the average by a different wind velocity at the top as indicated on fig. 21. If the differences between the wind at the top and the wind at the bottom, Δv, be taken and plotted as ordinates to the wind velocity at the bottom, the points appear on fig. 22 near the line marked pan 7 at the top of the tower. It is nearly a straight line, making an angle $\alpha = 22° 20'$ with the base. The precepts leading to the general formula,

$$v_1 = v + 0.410 \frac{h}{h_0} v, \tag{28}$$

are given in fig. 22, where v is the velocity at the bottom, h the height of the pan and h_0 the height of the tower, v_1 the required velocity at a given pan. Practically the mean velocities of the English anemometer were obtained separately for the six weeks of the observations. The special metric anemometer readings were sorted into groups for each tower for winds between the limits: 0–5, 5–10, 10–15, ... 45–50 kilometers per hour at the bottom, middle, and top of the towers, and plotted on diagrams. Mean sloping lines were drawn individually and then intermediate lines from the velocities at the bottom, 0, 5, 10, ... 40, 45. The readings at the top were scaled from the diagrams and they are given in Table 7, increase in the wind velocity from bottom to top of the tower, the bottom meaning the water surface for towers Nos. 2, 3, and 4, and the ground for Nos. 1 and 5.

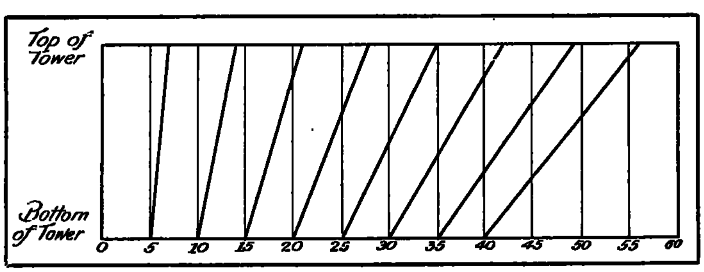

FIG. 21.—Wind velocities at bottom and top of towers, kil./hour.

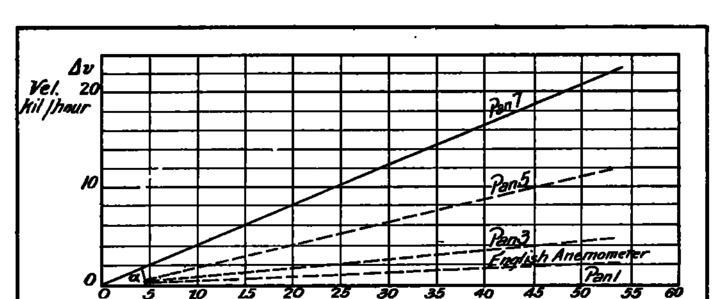

FIG. 22.—The vertical ordinate gives the increase of the wind velocity at the higher point over that at the lower point.

v = velocity at the bottom of the tower.

v_1 = velocity at the higher point.

$$v_1 = v + v \tan a = v\ (1 + \tan a).$$

For the top of the tower, pan 7, $a = 22°\ 20'$

$$v_1 = v + v \tan 22°\ 20' = v\ (1 + 0.41) = 1.41\ v.$$

The velocity of the English anemometer is transferred to other heights, pan 1, pan 3, pan 5, pan 7, by adding the proper ordinates from this diagram.

General formula.

$$v_1 = v + 0.41 \frac{h}{h_0} v, \text{ where}$$

h_0 = height of the tower and
h = height of the pan.

TABLE 7.—*Increase in the wind velocity from the base to the top of the towers.*
v = velocity in kilometers per hour.

Tower.	Base.	Top.	Base.	Top.	Base.	Top.	Base.	Top.	Base.	Top.
No. 1	5.0	6.7	10.0	13.6	15.0	21.4	20.0	28.7	25.0	35.6
No. 2		8.3		15.0		21.2		28.4		36.1
No. 3		6.6		11.6		18 1		26.2		32.7
No. 4		7.4		13.8		21.2		29.8		37.8
No. 5		7.0		13.8		20.9		28.0		35.2
v	5.0	7.20	10.0	13.56	15.0	20.56	20.0	28.12	25.0	35.48
Δv	2.20		3.56		5.56		8.12		10.48	

Tower.	Base.	Top.	Base.	Top.	Base.	Top.	Base.	Top.
No. 1	30.0	41.6	35.0	46.5	40.0	52.7	45.0	58.8
No. 2		44.6		52.4		60.8		....
No. 3		39.0		46.7		54.5		62.3
No. 4		45.3		52.5		60.9		....
No. 5		41.8		48.5		56.3		....
v	30.0	42.46	35.0	49.32	40.0	57.04	45.0	60.55
Δv	12.46		14.32		17.04		15.55	

The differences in the wind velocity Δv are plotted near the line pan 7 in fig. 22.

The entire system of meteorological data has been sorted out into three groups, namely, those in which the wind velocity at the pan 1 lies between the limits 1–10, 10–20, 20–40 kilometers per hour. The wind values for these groups at each of the pans 1, 3, 5, and 7 have been computed, that is, the average wind for the actual hours of the observations from August 1 to September 15, with the result that the following wind velocities have been used in the reduction of the observations, after smooth lines have been drawn thru the diurnal variations. The mean values for the three-hour intervals have been employed, for the sake of the integration of the evaporation.

TABLE 8.—*Mean wind velocities at the pans 1, 3, 5, and 7 for the three-hour intervals ending with the given hour.*

Wind.	2 *a*	5 *a*	8 *a*	11 *a*	2 *p*	5 *p*	8 *p*	11 *p*
PAN 7.								
1–10 w_1	3	2	3	5	7	8	6	3
10–20 w_2	18	17	19	21	22	22	21	19
20–40 w_3	32	31	31	34	37	38	37	34
PAN 5.								
1–10 w_1	2	2	3	4	6	7	5	3
10–20 w_2	16	15	17	19	20	20	19	17
20–40 w_3	28	27	27	30	33	33	32	30
PAN 3.								
1–10 w_1	2	2	2	4	5	6	4	3
10–20 w_2	14	13	15	17	18	17	16	15
20–40 w_3	24	23	23	26	28	29	27	25
PAN 1.								
1–10 w_1	2	1	2	4	6	6	4	2
10–20 w_2	13	13	14	16	17	17	15	14
20–40 w_3	22	21	22	25	27	28	26	24

In spite of the fact that the number of observations is large, yet when they are distributed into these three groups of wind velocities, and they are to be carried thru the eight groups of three-hour intervals for the twenty-four hours of the day, in order to discuss the diurnal period, there is a failure of observations during the night and morning hours, while the data are quite reliable during the afternoon hours. It has been necessary to control the actual observations by the construction of diurnal curves of all the elements, in order to secure approximate mean values. Since the purpose of this research was to obtain a formula for further observations, and some general views regarding the subject of evaporation itself, it was thought proper to proceed in this manner. When one branch of a single-period diurnal curve is well defined, as from 11 a. m. to 8 p. m., it is easy to extend it to cover the twenty-four hours, provided the 5 a. m. or minimum point can be determined. We had sufficient observations for this purpose, and so have conducted the discussion of the observations in this way. It may be remarked in passing that the three-hour amounts of evaporation at pans 1, 3, 5, and 7 on the five towers were plotted in two ways in succession under the three wind groups, in order that the observations might mutually adjust themselves over the gaps where the number of them is not adequate. (1) The four evaporations for the several pans were *first grouped under the three wind velocities* 1–10, 10–20, 20–40, the curves being drawn by the observations which were rather irregular, except for the low wind velocity, 1–10, where the number of the observations is great. (2) Then these curves were re-collected so that the *three wind groups appear under each pan*, as on the diagrams of figs. 23–27. This method of double plotting of curves and mutual adjustment is very efficient in dealing with insufficient data.

It is quite impracticable to reproduce the original data in this paper, on account of its bulk, nor is it possible to describe the numerous tentative attempts to discover a formula which seems to be capable of accounting for the numerous variations. We shall proceed at once to the finished product so far as the data are concerned, and make only a few remarks regarding the preliminary formulas. Tables 9, 10, 11, 12, and 13, contain the dry-bulb temperature t, the temperature of the surface of the water S, the vapor pressure e of the air computed from the table with the arguments t_1 the wet-bulb temperature, and $t-t_1$, and the evaporation E for every three successive hours thruout the day. The data given in these tables were scaled from the diurnal curves which have been constructed as stated, and the curves may be readily reproduced for study. Under each element t, S, e, E are given separately the results for each of the wind groups, 1–10, 10–20, 20–40, the sorting being now carried, not to individual days when these winds prevailed, but to individual hours. Since the high winds occurred chiefly in the afternoon, it gave much more data for the hours noon to midnight than for the hours midnight to noon. This lack of balance made the discussion of the observations rather difficult, and will justify a longer campaign in the Salton Sink, extending over several years. On figs. 23, 24, 25, 26, and 27 are given the evaporation curves corresponding with the data on Tables 9–13, and they are also the direct results of the formula that has been adopted.

A comparison of these data with the original rough data shows that the computed results represent the observations as well as practicable, except possibly at the 8 p. m. ordinate, which seems rather large. The evaporation may be found to drop more rapidly than the formula permits without a minor correction. This difficulty may disappear as the result of a better determination of the evaporation curves. On plotting the temperature curves together, t, S, as in fig. 28 for tower No. 1, it is seen that the temperature of the pans on the

TABLE 9.—*Tower No. 1, in dry field east of reservoir. Meteorological data.*

PAN 1.

Symbol.	Wind.	A. M. 2	5	8	11	P. M. 2	5	8	11	Mean.	Hour of mean ordinate. a. m.	p. m.
t	0-10	12.3	11.6	16.0	23.0	25.6	23.4	18.1	15.0	18.1	......	......
	10-20	14.8	14.4	20.0	25.7	27.5	23.4	16.8	16.0	19.8	......	......
	20-40	16.2	16.6	20.8	24.3	27.5	26.0	19.5	17.2	21.0	......	......
S	0-10	11.5	10.3	12.1	18.4	24.6	24.3	20.2	15.1	17.1	......	......
	10-20	15.7	15.7	17.0	21.0	24.9	22.0	17.8	16.4	18.8	......	......
	20-40	15.0	14.9	16.4	20.3	24.0	20.9	17.3	15.8	18.1	......	......
e	0-10	5.6	6.0	6.8	6.8	6.7	6.2	5.7	5.6	6.2	......	......
	10-20	6.5	6.9	7.0	7.0	6.8	6.5	6.1	6.1	6.6	......	......
	20-40	6.4	6.7	6.8	6.9	6.7	6.4	6.0	6.0	6.5	......	......
E	0-10	.135	.110	.127	.167	.245	.266	.220	.172	.180	11.5	10.5
	10-20	.164	.135	.157	.217	.328	.344	.278	.212	.229	11.5	10.3
	20-40	.190	.150	.178	.244	.370	.397	.320	.242	.261	11.5	10.4

PAN 3.

Symbol.	Wind.	A. M. 2	5	8	11	P. M. 2	5	8	11	Mean.	a. m.	p. m.
t	0-10	12.6	11.3	16.2	22.8	25.0	22.8	18.0	15.0	18.0	......	......
	10-20	15.0	14.8	19.2	24.7	26.6	22.6	17.5	16.0	19.6	......	......
	20-40	17.0	16.6	20.0	24.0	26.4	25.7	20.2	18.0	21.0	......	......
S	0-10	11.6	10.2	12.5	19.0	24.3	24.2	20.2	15.0	17.1	......	......
	10-20	15.0	15.2	18.0	22.0	24.8	21.4	17.6	15.8	18.7	......	......
	20-40	14.5	14.7	17.0	20.6	23.2	20.3	16.8	15.0	17.8	......	......
e	0-10	5.7	6.1	6.8	6.5	6.4	6.0	5.7	5.7	6.1	......	......
	10-20	6.3	6.7	6.8	6.5	6.0	5.7	5.7	5.9	6.2	......	......
	20-40	5.9	6.2	6.4	6.2	5.7	5.5	5.5	5.7	5.9	......	......
E	0-10	.137	.118	.130	.172	.243	.270	.222	.177	.184	11.6	10.5
	10-20	.172	.144	.166	.230	.320	.347	.282	.220	.235	11.5	9.8
	20-40	.200	.170	.185	.260	.365	.402	.337	.258	.272	11.4	10.4

PAN 5.

Symbol.	Wind.	A. M. 2	5	8	11	P. M. 2	5	8	11	Mean.	a. m.	p. m.
t	0-10	12.8	11.7	16.2	22.2	24.6	23.0	19.8	16.5	18.3	......	......
	10-20	15.0	14.7	19.2	24.7	26.0	22.8	18.8	17.0	19.8	......	......
	20-40	16.3	16.2	20.0	24.0	26.0	25.3	20.7	18.2	20.8	......	......
S	0-10	11.8	11.0	12.9	19.4	24.2	23.5	19.2	15.0	17.1	......	......
	10-20	15.4	15.6	18.0	21.7	24.2	22.0	17.3	16.1	18.8	......	......
	20-40	14.8	14.8	17.0	20.0	22.2	20.0	16.7	15.7	17.6	......	......
e	0-10	5.5	5.6	6.6	6.3	6.3	5.7	5.6	5.4	5.9	......	......
	10-20	6.3	6.6	6.8	6.5	5.9	5.6	5.6	5.7	6.1	......	......
	20-40	5.9	6.3	6.5	6.0	5.6	5.4	5.4	5.6	5.8	......	......
E	0-10	.152	.130	.146	.200	.270	.287	.230	.186	.200	11.0	10.1
	10-20	.195	.165	.192	.265	.362	.386	.310	.250	.266	11.0	9.8
	20-40	.230	.192	.218	.306	.430	.454	.360	.308	.312	11.0	9.9

PAN 7.

Symbol.	Wind.	A. M. 2	5	8	11	P. M. 2	5	8	11	Mean.	a. m.	p. m.
t	0-10	13.7	12.1	16.7	22.3	24.6	22.6	18.6	16.0	18.3	......	......
	10-20	15.6	15.1	19.0	24.2	26.0	22.0	18.0	16.3	19.5	......	......
	20-40	16.4	16.2	20.0	24.0	25.4	25.0	20.6	18.2	20.7	......	......
S	0-10	11.8	10.5	13.0	19.7	24.2	23.7	19.0	15.2	17.1	......	......
	10-20	14.1	14.4	17.0	20.8	24.0	20.3	16.4	15.0	17.8	......	......
	20-40	13.7	13.8	16.0	20.0	22.3	19.8	16.2	14.3	17.0	......	......
e	0-10	5.5	5.9	6.7	6.3	6.2	5.4	5.2	5.3	5.8	......	......
	10-20	6.2	6.6	6.8	6.6	6.0	5.6	5.5	5.4	6.1	......	......
	20-40	5.8	6.3	6.6	6.2	5.8	5.4	5.3	5.2	5.8	......	......
E	0-10	.154	.134	.154	.210	.287	.295	.235	.186	.207	10.8	9.5
	10-20	.206	.173	.208	.294	.396	.410	.320	.250	.282	10.7	9.4
	20-40	.248	.210	.243	.340	.475	.490	.400	.307	.339	10.9	9.8

TABLE 10.—*Tower No. 2, on eastern bank of reservoir. Meteorological data.*

PAN 1.

Symbol.	Wind.	A. M. 2	5	8	11	P. M. 2	5	8	11	Mean.	a. m.	p. m.
t	0-10	13.7	11.8	16.9	23.0	24.7	22.8	21.2	17.0	18.9	......	......
	10-20	15.9	15.0	20.8	24.6	25.7	23.3	19.3	17.0	20.2	......	......
	20-40	17.0	16.7	20.0	21.7	24.8	24.0	20.0	18.1	20.3	......	......
S	0-10	14.9	14.7	17.3	20.8	21.2	20.2	18.6	16.6	18.0	......	......
	10-20	16.0	16.8	19.4	20.7	21.5	19.0	16.7	16.0	18.3	......	......
	20-40	15.0	15.2	17.0	18.4	19.7	18.0	16.0	15.0	16.8	......	......
e	0-10	6.2	6.4	7.3	7.3	7.2	6.9	6.7	6.4	6.8	......	......
	10-20	6.7	7.2	8.3	7.7	7.8	7.7	6.7	6.5	7.3	......	......
	20-40	6.4	6.5	7.0	7.3	7.0	7.0	6.4	6.2	6.7	......	......
E	0-10	.130	.118	.140	.181	.202	.191	.172	.148	.160	9.4	9.0
	20-20	.159	.140	.178	.222	.260	.250	.220	.187	.202	9.6	9.4
	20-40	.180	.158	.198	.260	.297	.288	.252	.212	.231	9.5	9.5

TABLE 10.—*Tower No. 2*—Continued.

PAN 3.

Symbol.	Wind.	A. M. 2	5	8	11	P. M. 2	5	8	11	Mean.	Hour of mean ordinate. a. m.	p. m.
t	0-10	14.2	11.5	16.7	23.2	25.1	23.0	21.4	16.4	18.9	......	......
	10-20	14.6	15.0	19.8	24.2	26.2	24.0	19.2	18.0	20.1	......	......
	20-40	17.2	17.2	20.1	21.8	25.7	24.6	20.0	18.0	20.6	......	......
S	0-10	11.2	9.8	13.0	19.0	23.3	23.4	20.4	15.8	17.0	......	......
	10-20	12.3	11.8	16.0	20.2	23.8	21.0	16.2	14.2	16.9	......	......
	20-40	11.2	10.6	13.5	18.1	21.5	19.4	15.0	12.9	15.3	......	......
e	0-10	5.7	5.9	6.9	6.9	7.0	6.7	6.0	5.7	6.4	......	......
	10-20	6.4	7.2	8.0	6.5	6.7	6.7	5.8	5.7	6.6	......	......
	20-40	5.6	5.7	5.5	6.0	5.9	6.0	5.9	5.7	5.8	......	......
E	0-10	.130	.103	.117	.175	.241	.264	.220	.164	.177	11.1	10.4
	10-20	.164	.128	.150	.230	.320	.340	.287	.220	.230	11.0	10.5
	20-40	.190	.150	.182	.276	.362	.395	.315	.250	.265	10.6	10.3

PAN 5.

Symbol.	Wind.	A. M. 2	5	8	11	P. M. 2	5	8	11	Mean.	a. m.	p. m.
t	0-10	14.1	11.5	16.4	23.3	24.3	22.3	22.6	17.8	19.0	......	......
	10-20	16.1	16.2	21.0	24.5	25.2	23.4	19.7	18.6	20.6	......	......
	20-40	18.0	18.0	20.7	21.4	25.1	24.1	20.2	18.7	20.8	......	......
S	0-10	11.6	9.7	14.1	20.5	24.2	23.0	19.7	15.6	17.3	......	......
	10-20	12.2	12.0	17.2	21.3	23.0	20.0	15.8	13.8	16.9	......	......
	20-40	11.3	11.0	15.0	18.8	20.8	18.2	14.2	12.2	15.2	......	......
e	0-10	5.2	5.3	6.6	6.1	6.3	6.0	5.2	5.0	5.7	......	......
	10-20	5.7	7.0	8.0	6.1	6.2	6.0	5.4	5.2	6.2	......	......
	20-40	5.3	5.7	5.8	5.8	5.7	5.5	5.2	5.1	5.5	......	......
E	0-10	.143	.118	.143	.213	.270	.292	.240	.186	.201	10.6	10.1
	10-20	.192	.150	.188	.282	.360	.395	.322	.241	.266	10.4	9.8
	20-40	.222	.172	.212	.327	.423	.460	.370	.298	.310	10.6	10.4

PAN 7.

Symbol.	Wind.	A. M. 2	5	8	11	P. M. 2	5	8	11	Mean.	a. m.	p. m.
t	0-10	14.3	12.0	17.7	23.0	24.7	22.0	22.6	19.0	19.4	......	......
	10-20	16.0	16.3	22.1	24.8	25.8	23.5	20.0	17.8	20.8	......	......
	20-40	17.8	17.9	20.4	21.2	24.7	23.9	20.2	18.9	20.6	......	......
S	0-10	11.6	9.7	14.7	21.0	24.0	22.2	19.0	15.4	17.2	......	......
	10-20	12.2	12.1	17.1	21.6	23.0	19.2	15.7	13.4	16.8	......	......
	20-40	11.1	11.0	14.6	18.8	20.2	17.8	14.0	12.1	15.0	......	......
e	0-10	5.3	5.5	6.6	6.3	6.4	6.1	5.6	5.5	5.9	......	......
	10-20	5.8	6.8	7.9	6.0	6.9	6.1	5.5	5.5	6.3	......	......
	20-40	5.5	5.6	5.5	5.6	5.7	5.3	5.1	5.2	5.4	......	......
E	0-10	.153	.123	.152	.232	.292	.307	.250	.192	.213	10.5	9.8
	10-20	.200	.160	.200	.315	.407	.420	.340	.243	.286	10.4	9.5
	20-40	.242	.185	.240	.370	.480	.505	.407	.307	.342	10.4	9.9

TABLE 11.—*Tower No. 3, on dike in midst of reservoir. Meteorological data.*

PAN 1.

Symbol.	Wind.	A. M. 2	5	8	11	P. M. 2	5	8	11	Mean.	a. m.	p. m.
t	0-10	18.0	11.6	15.8	22.0	24.1	22.0	21.7	16.7	18.4	......	......
	10-20	15.7	15.8	19.5	21.5	24.0	23.3	19.8	17.0	19.6	......	......
	20-40	16.0	14.7	18.0	19.4	24.0	24.3	20.0	17.8	19.3	......	......
S	0-10	16.1	15.3	16.7	19.7	21.3	20.0	18.3	17.2	18.1	......	......
	10-20	17.6	17.8	18.0	19.2	21.2	20.2	18.0	17.5	18.7	......	......
	20-40	16.9	17.0	17.6	18.4	20.2	19.3	17.0	16.7	17.9	......	......
e	0-10	6.6	6.7	7.0	7.5	7.3	7.0	7.0	7.0	7.0	......	......
	10-20	7.3	8.8	8.7	6.7	7.8	7.3	6.5	6.5	7.4	......	......
	20-40	5.4	5.8	6.6	6.3	7.1	7.6	6.3	5.7	6.3	......	......
E	0-10	.105	.100	.095	.120	.140	.140	.127	.112	.117	10.3	10.5
	10-20	.130	.118	.116	.153	.182	.177	.158	.138	.147	10.5	10.4
	20-40	.148	.132	.133	.177	.207	.203	.182	.157	.167	10.4	10.4

PAN 3.

Symbol.	Wind.	A. M. 2	5	8	11	P. M. 2	5	8	11	Mean.	a. m.	p. m.
t	0-10	18.1	11.4	16.8	22.8	24.8	22.0	21.2	17.7	18.7	......	......
	10-20	16.4	16.3	20.5	22.8	25.2	24.1	18.8	17.6	20.2	......	......
	20-40	16.6	16.2	19.4	20.1	25.0	24.2	19.5	17.9	19.9	......	......
S	0-10	18.7	16.0	15.2	21.8	26.3	25.8	24.0	21.7	21.2	......	......
	10-20	14.9	14.2	16.6	22.0	26.0	25.0	19.7	16.0	19.3	......	......
	20-40	13.8	13.2	14.7	18.3	23.7	22.0	17.3	15.0	17.2	......	......
e	0-10	6.1	6.2	7.1	7.5	7.1	6.7	6.2	6.1	6.6	......	......
	10-20	6.8	8.1	8.8	7.0	7.8	7.0	6.1	6.5	7.3	......	......
	20-40	5.7	5.5	6.3	5.8	6.3	6.9	6.3	5.6	6.0	......	......
E	0-10	.163	.142	.132	.170	.240	.246	.220	.190	.188	11.7	11.3
	10-20	.204	.177	.160	.220	.312	.320	.280	.240	.239	11.5	11.2
	20-40	.238	.198	.182	.252	.360	.368	.320	.275	.274	11.5	11.1

Table 11.—*Tower No. 3*—Continued.

PAN 5.

Symbol.	Wind.	A. M. 2	A. M. 5	A. M. 8	A. M. 11	P. M. 2	P. M. 5	P. M. 8	P. M. 11	Mean.	Hour of mean ordinate. a. m.	Hour of mean ordinate. p. m.
t	0–10	14.0	12.0	16.0	21.4	24.2	22.0	21.7	18.0	18.9		
	10–20	17.4	17.0	20.0	21.8	25.2	24.1	19.7	18.1	20.4		
	20–40	17.0	16.8	18.2	20.0	24.2	24.6	20.0	18.1	19.9		
S	0–10	12.3	10.3	13.2	16.5	20.7	20.4	19.2	16.0	16.1		
	10–20	13.8	13.8	15.2	15.0	20.5	20.2	16.2	14.6	16.3		
	20–40	12.8	12.2	13.0	16.0	19.2	18.8	14.7	13.7	15.0		
e	0–10	5.4	5.8	6.8	6.6	6.1	6.0	5.4	5.2	5.9		
	10–20	6.3	7.4	7.5	5.6	6.1	5.5	5.2	5.6	6.2		
	20–40	4.8	4.8	5.6	4.8	5.3	5.5	5.4	5.0	5.2		
E	0–10	.143	.124	.141	.182	.217	.222	.204	.175	.176	10.6	11.1
	10–20	.185	.155	.180	.240	.292	.297	.272	.228	.231	10.6	10.8
	20–40	.220	.184	.210	.277	.342	.346	.314	.262	.269	10.8	10.6

PAN 7.

Symbol.	Wind.	A. M. 2	A. M. 5	A. M. 8	A. M. 11	P. M. 2	P. M. 5	P. M. 8	P. M. 11	Mean.	a. m.	p. m.
t	0–10	14.2	12.1	16.7	22.2	23.2	22.0	22.2	17.7	18.8		
	10–20	16.9	17.6	21.4	22.0	23.9	23.4	19.0	17.5	20.2		
	20–40	17.5	18.0	19.8	21.0	24.4	24.0	19.7	18.2	20.3		
S	0–10	12.8	10.2	14.0	20.7	24.0	21.2	19.5	16.0	17.2		
	10–20	14.0	14.2	17.1	20.7	22.3	21.2	17.0	14.4	17.6		
	20–40	12.9	12.7	15.0	18.1	20.4	19.0	14.9	13.4	15.8		
e	0–10	5.2	5.6	6.6	6.7	5.7	5.6	5.2	5.1	5.7		
	10–20	6.7	7.7	7.5	6.0	6.0	5.7	5.3	5.7	6.3		
	20–40	5.2	5.1	5.1	4.8	5.3	5.4	5.5	5.2	5.2		
E	0–10	.154	.130	.160	.240	.283	.268	.220	.183	.205	9.8	8.8
	10–20	.205	.170	.211	.330	.395	.367	.300	.247	.278	9.8	8.9
	20–40	.246	.204	.246	.382	.470	.440	.360	.297	.331	9.7	9.2

Table 12.—*Tower No. 4, on western bank of reservoir. Meteorological data.*

PAN 1.

Symbol.	Wind.	A. M. 2	A. M. 5	A. M. 8	A. M. 11	P. M. 2	P. M. 5	P. M. 8	P. M. 11	Mean.	a. m.	p. m.
t	0–10	12.4	11.6	17.4	21.8	24.2	22.0	18.0	15.6	17.9		
	10–20	15.3	15.2	20.2	24.4	25.5	24.0	18.8	17.0	20.0		
	20–40	17.9	18.0	21.7	23.9	25.0	24.0	19.0	18.3	21.0		
S	0–10	15.8	16.0	18.0	21.0	21.0	19.7	17.4	16.2	18.1		
	10–20	16.6	17.5	19.0	21.4	22.0	19.4	17.0	16.5	18.7		
	20–40	16.0	16.7	18.2	20.2	20.2	18.3	16.7	16.0	17.8		
e	0–10	6.2	6.8	7.6	7.8	7.4	7.7	6.4	6.0	6.9		
	10–20	6.7	8.0	8.5	7.1	7.3	6.9	6.4	6.3	7.2		
	20–40	6.4	6.4	6.0	6.1	7.0	6.7	6.1	6.0	6.3		
E	0–10	.130	.125	.150	.200	.210	.198	.168	.140	.165	9.1	8.3
	10–20	.158	.155	.190	.255	.272	.258	.210	.168	.208	8.9	8.3
	20–40	.180	.174	.210	.286	.306	.290	.246	.193	.236	8.9	8.7

PAN 3.

Symbol.	Wind.	A. M. 2	A. M. 5	A. M. 8	A. M. 11	P. M. 2	P. M. 5	P. M. 8	P. M. 11	Mean.	a. m.	p. m.
t	0–10	12.8	11.2	17.2	23.8	26.0	22.0	18.3	16.5	18.5		
	10–20	15.4	15.0	19.0	23.6	25.9	24.0	18.0	16.6	19.7		
	20–40	18.2	18.0	21.0	23.4	25.3	24.2	19.2	18.1	20.9		
S	0–10	13.7	11.0	12.3	17.2	21.4	22.7	21.0	17.3	17.1		
	10–20	15.8	15.6	18.0	19.7	20.7	20.6	17.8	16.2	18.0		
	20–40	14.7	14.2	16.0	18.3	20.0	19.5	16.3	15.4	16.8		
e	0–10	5.8	6.2	8.0	8.2	8.1	7.8	6.0	5.5	7.0		
	10–20	5.9	7.0	8.0	8.3	8.4	8.0	6.0	5.4	7.1		
	20–40	5.9	6.4	7.6	7.0	8.2	6.7	5.5	5.1	6.6		
E	0–10	.157	.132	.150	.205	.268	.303	.260	.200	.209	11.2	10.6
	10–20	.196	.160	.194	.267	.357	.397	.340	.260	.271	11.3	10.6
	20–40	.225	.184	.220	.300	.405	.462	.388	.303	.311	11.4	10.7

PAN 5.

Symbol.	Wind.	A. M. 2	A. M. 5	A. M. 8	A. M. 11	P. M. 2	P. M. 5	P. M. 8	P. M. 11	Mean.	a. m.	p. m.
t	0–10	14.2	12.2	18.2	23.8	24.7	22.0	21.0	17.7	19.2		
	10–20	16.9	16.7	20.0	24.0	26.0	24.0	19.2	18.1	20.6		
	20–40	18.3	18.5	21.0	23.0	25.0	24.4	19.5	18.8	21.1		
S	0–10	13.0	10.6	15.6	22.2	24.4	23.0	19.7	16.2	18.1		
	10–20	13.0	12.6	16.5	21.1	24.1	21.0	16.3	14.0	17.3		
	20–40	12.8	12.0	14.9	19.8	22.0	19.0	15.5	13.6	16.1		
e	0–10	5.7	5.8	7.2	6.9	6.4	6.1	5.9	5.7	6.2		
	10–20	6.1	7.1	8.1	6.5	6.1	5.7	5.5	5.6	6.3		
	20–40	5.8	6.5	6.9	6.2	5.9	5.8	5.5	5.5	6.0		
E	0–10	.157	.141	.168	.260	.282	.272	.220	.183	.210	9.4	8.5
	10–20	.197	.178	.220	.350	.382	.365	.292	.240	.278	9.2	8.8
	20–40	.233	.210	.260	.405	.450	.430	.340	.282	.326	9.6	8.6

Table 12.—*Tower No. 4*—Continued.

PAN 7.

Symbol.	Wind.	A. M. 2	A. M. 5	A. M. 8	A. M. 11	P. M. 2	P. M. 5	P. M. 8	P. M. 11	Mean.	Hour of mean ordinate. a. m.	Hour of mean ordinate. p. m.
t	0–10	14.0	12.3	18.1	23.5	24.3	22.0	20.6	17.6	19.0		
	10–20	17.0	16.5	20.3	24.3	26.0	24.0	19.2	17.8	20.6		
	20–40	18.2	18.4	21.1	23.8	25.0	21.0	19.4	18.2	20.6		
S	0–10	12.3	10.9	16.2	22.5	24.2	22.2	19.0	15.9	17.9		
	10–20	13.0	13.4	18.0	21.9	23.9	20.0	16.0	14.2	17.6		
	20–40	12.3	12.7	16.0	20.0	20.7	18.3	15.2	13.2	16.0		
e	0–10	5.9	5.8	6.8	6.6	6.0	5.8	6.0	5.9	6.1		
	10–20	6.0	6.9	8.1	6.5	5.8	5.6	5.5	5.6	6.2		
	20–40	5.4	5.9	6.4	6.1	5.6	5.4	5.3	5.4	5.7		
E	0–10	.160	.157	.183	.284	.292	.274	.220	.180	.219	9.0	8.0
	10–20	.218	.205	.252	.394	.410	.380	.300	.253	.302	9.1	8.0
	20–40	.266	.242	.290	.460	.482	.458	.364	.302	.358	8.9	8.3

Table 13.—*Tower No. 5, in the irrigated field west of reservoir. Meteorological data.*

PAN 1.

Symbol.	Wind.	A. M. 2	A. M. 5	A. M. 8	A. M. 11	P. M. 2	P. M. 5	P. M. 8	P. M. 11	Mean.	a. m.	p. m.
t	0–10	12.0	11.0	19.6	22.8	23.6	20.0	19.0	16.0	18.0		
	10–20	15.8	15.4	21.0	24.7	24.5	19.6	18.3	17.3	19.6		
	20–40	17.0	17.1	22.0	25.1	25.3	22.2	19.7	18.2	20.8		
S	0–10	11.7	9.4	16.0	21.5	23.0	23.7	20.0	15.4	17.6		
	10–20	16.2	16.0	16.9	21.7	24.1	21.6	17.7	16.7	18.9		
	20–40	15.8	15.7	16.1	20.0	22.6	20.6	17.5	16.2	18.1		
e	0–10	5.4	6.0	8.3	8.6	8.2	7.0	5.3	5.2	6.8		
	10–20	5.7	6.0	7.2	8.1	7.5	6.5	5.9	5.6	6.6		
	20–40	5.6	5.8	7.4	6.6	6.3	6.3	5.8	5.5	6.2		
E	0–10	.103	.090	.124	.210	.262	.250	.192	.142	.172	9.6	9.2
	10–20	.133	.105	.160	.280	.340	.326	.224	.180	.218	9.3	9.2
	20–40	.150	.118	.184	.320	.386	.375	.283	.206	.253	10.2	9.1

PAN 3.

Symbol.	Wind.	A. M. 2	A. M. 5	A. M. 8	A. M. 11	P. M. 2	P. M. 5	P. M. 8	P. M. 11	Mean.	a. m.	p. m.
t	0–10	13.7	17.0	19.6	23.0	24.3	21.0	21.2	17.2	19.6		
	10–20	16.5	16.1	21.4	24.8	24.8	19.2	18.9	18.1	19.9		
	20–40	17.7	17.0	21.0	24.8	25.2	23.0	21.6	19.2	21.2		
S	0–10	12.0	9.7	16.7	22.2	24.3	23.5	20.7	16.8	18.2		
	10–20	12.8	13.0	18.0	22.7	24.0	20.0	16.0	14.4	17.6		
	20–40	12.2	12.4	17.0	20.7	21.8	19.0	15.7	13.9	16.6		
e	0–10	5.3	5.8	7.3	7.1	6.8	6.2	5.1	4.6	6.0		
	10–20	4.5	5.0	7.0	7.9	6.3	5.5	4.7	4.6	5.7		
	20–40	4.2	4.7	5.2	5.5	5.6	5.4	4.6	4.5	5.0		
E	0–10	.160	.128	.178	.287	.328	.312	.245	.200	.230	9.5	8.8
	10–20	.200	.160	.220	.376	.430	.408	.320	.250	.296	9.5	8.9
	20–40	.227	.180	.258	.420	.488	.472	.366	.292	.338	9.4	9.1

PAN 5.

Symbol.	Wind.	A. M. 2	A. M. 5	A. M. 8	A. M. 11	P. M. 2	P. M. 5	P. M. 8	P. M. 11	Mean.	a. m.	p. m.
t	0–10	13.9	12.4	19.4	22.8	24.3	21.6	21.8	17.9	19.3		
	10–20	16.8	16.0	21.0	24.2	25.0	21.7	20.0	18.7	20.4		
	20–40	18.0	17.2	21.0	24.1	25.0	23.7	21.8	19.8	21.3		
S	0–10	12.7	10.2	16.6	22.2	24.5	23.4	20.6	17.0	18.4		
	10–20	11.8	12.0	17.3	22.6	23.2	19.6	15.8	12.5	16.8		
	20–40	11.2	11.7	16.2	21.0	21.8	18.8	15.4	12.0	16.0		
e	0–10	5.3	5.5	7.0	7.0	6.8	5.7	5.3	5.1	5.9		
	10–20	4.7	5.5	7.0	7.3	6.4	5.4	4.8	4.7	5.7		
	20–40	4.3	4.6	5.0	5.2	5.2	5.0	4.7	4.6	4.8		
E	0–10	.175	.140	.186	.295	.337	.318	.262	.217	.241	9.6	9.2
	10–20	.227	.180	.242	.395	.454	.425	.352	.286	.320	9.6	9.4
	20–40	.265	.210	.290	.450	.537	.500	.408	.337	.375	9.6	9.3

PAN 7.

Symbol.	Wind.	A. M. 2	A. M. 5	A. M. 8	A. M. 11	P. M. 2	P. M. 5	P. M. 8	P. M. 11	Mean.	a. m.	p. m.
t	0–10	14.7	12.7	19.4	23.0	24.8	21.8	22.2	18.5	19.6		
	10–20	16.9	16.0	20.6	24.3	24.9	21.4	20.0	18.5	20.3		
	20–40	17.6	17.2	21.2	24.2	25.0	23.7	21.6	19.2	21.2		
S	0–10	12.7	10.8	17.2	22.5	24.0	22.8	20.0	16.4	18.3		
	10–20	12.2	12.7	17.0	23.3	23.0	18.0	14.8	13.0	16.8		
	20–40	11.8	12.1	16.2	21.8	22.0	17.2	14.2	12.8	16.0		
e	0–10	5.4	5.5	6.9	6.8	6.0	5.5	5.5	5.4	5.9		
	10–20	4.5	5.1	7.1	7.9	6.0	5.2	4.8	4.7	5.7		
	20–40	4.2	4.6	5.2	5.3	5.1	5.0	4.7	4.6	4.8		
E	0–10	.188	.154	.196	.300	.336	.310	.264	.205	.244	9.5	9.8
	10–20	.248	.200	.258	.426	.465	.428	.360	.270	.332	9.4	9.4
	20–40	.300	.240	.300	.500	.550	.510	.432	.317	.394	9.3	9.5

tower lags about two hours behind that of the air in the forenoon, and one hour in the afternoon; on tower No. 2 the dry-bulb temperature shows a strong double period, while that for the water does not have the second maximum; the vapor tension e has generally a maximum about 8 a. m., and a smaller maximum at 3 p. m., especially during the middle type of the wind velocities 10–20 kilometers per hour. The plotted curves are very interesting and they will repay careful examination, as they contain much valuable information regarding the action of the solar radiation in the lower strata. In constructing the proposed formula, the element S, the temperature of the water surface, e, the vapor pressure, and w, the wind velocity, have been incorporated into it.

The temperature of the water surface is a function of the amount of vapor in cubic centimeters v_1 which one cubic centimeter of water, v_2, will make at that temperature. The vapor pressure of the air e_d and that within one-half inch of the surface of the water e_r run in parallel lines, as shown on figs. 6–12 in Paper II of this series, so that the function of the evaporation can be built up in terms of one as well as the other, while the psychrometer will be the best instrument for use, as the floating raft thermometers are liable to get wet in the splashing water. Since the vapor pressure prevailing in the air holds close down to the water surface with no special change, it follows that the distribution of the vapor within the air, after one-half an inch has been past, goes off into the higher levels quite gradually. The first rise in vapor pressure at 8 a. m., before the heat renders the air capable of holding more vapor, marks the tendency of the evaporating vapor to change the cool morning air over the water pans.

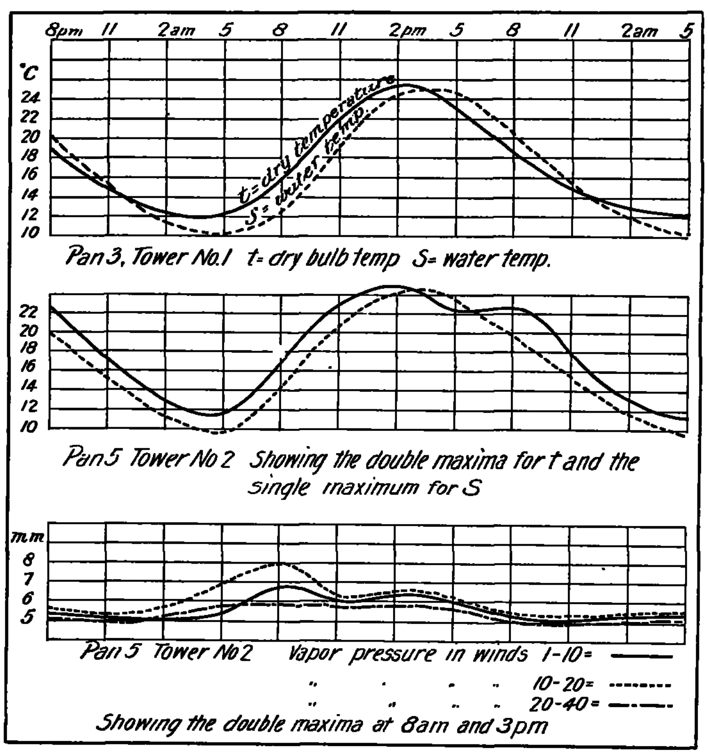

FIG. 28.

These irregularities in the meteorological data are probably due to the local conditions. In the forenoon the wind was usually feeble from the southeast; in the afternoon it was strong from the west and brought cold air from the Sierra Nevada Mountains, which flowed down the Truckee River Valley. The wind blowing over the reservoir affected the pans differently on the leeward or eastward side. The evaporation, doubtless, responded to all these characteristics, but it was not possible to disentangle all these elements in the short Reno campaign.

THE FORMULAS FOR THE EVAPORATION OF WATER.

The formula that has been commonly used in discussing the amount of the evaporation is in the form of the Dalton law.

$$E = C\,(e_s - e_d)\,(1 + Av), \tag{29}$$

where C is a constant, e_s the vapor pressure at the temperature of the water, e_d the vapor pressure at the temperature of the dew-point, A the wind constant, and v the velocity of the wind. It was shown by comparing the results of the observations at Abbassia, Boston, Fort Collins, and Nakuss that the constants are very inconsistent, and it was inferred that the formula is not satisfactory. The relations of $e_s - e_d$ are shown on figs. 6–12, on the several towers and pans for seven hours in the day, and by comparing with the evaporation, figs. 13–19 it can be seen that there is a loose relationship between them, which has been the basis of this formula. By plotting the mean values of e_s, e_d on Table 5 and the means of the evaporation on Table 6 for each hour given, the diurnal curves may be readily constructed and the Dalton law studied. On computing the so-called constant C for the seven available hours for the observations August 1–17, we find the following result, putting all the towers together:

TABLE 14.—*Values of* $\frac{1}{C} = \frac{e_s - e_d}{E}$, *and C by Dalton's law.*

Pans.	1 a. m.	5 a. m.	8 a. m.	11 a. m.	2 p. m.	5 p. m.	8 p. m.	$\frac{1}{C}$	C
6, 7	33.1	23.5	39.8	43.1	36.1	35.7	35.5	35.3	0.0283
5	34.2	25.8	40.3	44.3	37.1	40.7	44.0	38.1	0.0263
4	36.6	25.6	38.8	51.4	47.0	46.2	32.4	39.7	0.0252
3	40.5	27.7	30.3	49.8	52.3	50.1	51.4	43.2	0.0232
2	44.4	30.4	34.2	56.7	67.4	60.4	58.3	50.3	0.0199
1	50.0	40.0	45.7	53.1	52.6	59.5	65.8	52.4	0.0191
Means $\frac{1}{C}$	39.8	28.8	38.2	49.7	48.7	48.8	47.9	43.2	....
C	.0252	.0348	.0262	.0202	.0206	.0205	.0209	....	....

The table shows a variation of C increasing up the towers and a diurnal period with maximum at 5 a. m. and minimum at 2 p. m. The wind term has not been eliminated in this computation of $\frac{1}{C}$ and C, but the results are evidently contradictory. If the increase of C up the towers is due to the increase of the wind velocity, then there should be an increase in the values of C in the afternoon over C in the forenoon, because there was at Reno a strong diurnal increase in the wind from morning to afternoon, as shown in Table 8.

I have, therefore, sought in many ways for a new formula and my final form is here presented, omitting the trial discussions from this paper. The following formula seemed for a time to be of value, but it was also superseded:

$$E = C\,\frac{de}{dS}\,(t - d)\,(1 + Aw^2), \tag{30}$$

where $\frac{de}{dS}$ is the rate of change in the vapor pressure per degree of temperature, as given in the Smithsonian Tables (Gray), Table 165, column 2, or the Meteorological Tables, Table 43; t = the temperature of the air, d the dew-point of the air, A the wind constant, and w the wind velocity in kilometers per hour. We have finally used the formula,

$$E = C f(h)\; e\,\frac{de}{dS}\,(1 + Aw), \tag{31}$$

where $Cf(h)$ is a variable, a function of the height, e the vapor pressure corresponding with the dew-point of the air, $\frac{de}{dS}$ the ratio of increase of the vapor pressure to the increase of the temperature, A a wind constant, and w the wind velocity in kilometers per hour. The computations were carried on in three parts under the formulas,

(32) $E = Cf(h)\, e \frac{de}{dS} + Cf(h)\, e \frac{de}{dS}\, Aw$, so that,

(33) $E_1 = E_1 + E_1\, Aw_1$ for w_1 between 1–10 km. per hour,

(34) $E_2 = E_1 + E_1\, Aw_2$ for w_2 between 10–20 km. per hour,

(35) $E_3 = E_1 + E_1\, Aw_3$ for w_3 between 20–40 km. per hour.

Since $E_1 Aw_1$ can practically be neglected, we have,

$$Cf(h) = \frac{E_1}{e \frac{de}{dS}}. \tag{36}$$

With the value of $Cf(h)$ thus found,

$$A = \frac{E_2 - E_1}{E_1 w_2} = \frac{E_3 - E_1}{E_1 w_3}. \tag{37}$$

There are two sets of values of the evaporation for computing the wind constant A, after the observations have given curves of evaporation sorted into the three sets as determined by the wind velocities. Thus, having such evaporation curves as are found on figs. 23–27, even if they are only approximately accurate, we can proceed by this process. Construct the values of $e \frac{de}{dS}$ and divide E_1 by it for the first group with the wind 0–10 kilometers per hour. This gives values of $Cf(h)$. Then take $E_2 - E_1$, $E_3 - E_1$, construct $E_1 w_2$, $E_1 w_3$, and divide for the constant A. It will be shown that $Cf(h)$ is the variable of an interesting function, while A is constant. The following tables give the value of $Cf(h)$ as computed from the rough curves derived directly from the observations, and A likewise derived from the observations of the second and third high wind velocity groups, 10–20, 20–40. The large number of observations available for the wind group 0–10 enabled us to construct the evaporation curve E_1 quite satisfactorily, the curves E_2 and E_3 being more difficult, as already explained, on account of the excess of high winds in the afternoon hours.

The line of thought which led to this formula may be summarized as follows: The well known Clayperon formula regulates the amount of vapor that can be derived from 1 cubic centimeter of water, when the vapor and water are at a certain temperature S, as already shown in the first paper[1] of this series, formula 18, from which we have, since v_2 can be neglected in comparison with v_1,

$$\frac{de}{dS} = \frac{r_2}{v_1 S_1}\, \frac{41852800 \times 760}{1013235} \tag{38}$$

since $e = p_1$, the vapor pressure, and $S_1 = T_1$ in the evaporation formula, for the sake of a distinctive notation. The mechanical equivalent of heat is taken 41852800 ergs, the pressure of 1 atmosphere 76 cm., or 1013235 dynes/cm. $= B_n \rho_m g_0 = 76 \times 13.5958 \times 980.60$, r_2 is the latent heat required to vaporize water at the temperature S_1, and v_1 the volume of vapor given off, ranging from $v_1 = 211356$ cm^3 at 0° C. to 1659 cm^3 at 100° C. The following table gives the values of $\frac{de}{dS}$ and r_2 for various temperatures.

The vapor pressure e was selected for this reason. In evaporation from a water surface the vapor pressure near the water e_r, within half an inch of the surface, should be a direct function of the diffusion of the vapor into the air, as shown by the figs. 6–12. Since the vapor pressure e_d of the dew-point of the air follows closely the e_r of the vapor down to the water I have substituted e_d for e_r because it is more conveniently observed, and the factor which connects them, e_r/e_d, is taken up into the function $Cf(h)$. This function has not yet been solved and it may throw further light on this point. $Cf(h)$ is concerned with the rate of diffusion and mixture of the vapor, which is streaming off into the adjacent air masses, and it represents the capacity of the superincumbent air to receive the new vapor more or less rapidly. The wind term Aw simply iscreases this absorbing capacity.

[1] Monthly Weather Review, July, 1907.

TABLE 15.—*The relations of S, $\frac{de}{dS}$ and r_2.*

S	$\frac{de}{dS}$	r_2	S	$\frac{de}{dS}$	r_2
°			°		
0	0.33	606.5	16	0.86	595.2
1	0.35	605.8	17	0.91	594.5
2	0.38	605.1	18	0.96	593.8
3	0.40	604.4	19	1.02	593.1
4	0.42	603.7	20	1.07	592.3
5	0.45	603.0	21	1.14	591.6
6	0.48	602.3	22	1.20	590.9
7	0.51	601.6	23	1.26	590.2
8	0.54	600.8	24	1.33	589.5
9	0.57	600.1	25	1.40	588.8
10	0.61	599.4	26	1.48	588.1
11	0.65	598.7	27	1.56	587.4
12	0.69	598.0	28	1.64	586.7
13	0.73	597.3	29	1.72	586.0
14	0.77	596.7	30	1.80	585.3
15	0.81	595.9			

TABLE 16.—*Computation of the term $Cf(h)$. Tower No. 1, pan 1.*

$$Cf(h) = \frac{E_1}{e \frac{de}{dS}}$$

Formula.	8 p. m.–1 a. m.	1–5 a. m.	5–8 a. m.	8–11 a. m.	11 a. m.–2 p. m.	2–5 p. m.	5–8 p. m.	Means.
S	15.8	10.8	10.7	15.4	22.8	24.9	22.7	
$\frac{de}{dS}$	0.85	0.64	0.64	0.83	1.25	1.39	1.24	
e	5.6	5.7	6.5	6.7	6.7	6.4	5.9	
$e \frac{de}{dS}$	4.8	3.6	4.2	5.6	8.4	8.9	7.3	
E_1	.097	.088	.138	.245	.300	.255	.162	
$Cf(h)$	.020	.025	.033	.044	.036	.029	.022	.030

TABLE 17.—*Computation of the mean diffusion function $Cf(h)$ from the three-hour observations.*

Pans.	8 p. m.–1 a. m.	1–5 a. m.	5–8 a. m.	8–11 a. m.	11 a. m.–2 p. m.	2–5 p. m.	5–8 p. m.	Means.
TOWER 1.								
1	.020	.025	.033	.044	.036	.029	.022	.030
3	.028	.028	.021	.040	.041	.033	.027	.031
5	.030	.031	.031	.039	.046	.037	.031	.035
7	.032	.035	.035	.039	.049	.041	.031	.037
TOWER 2.								
1	.029	.023	.023	.024	.026	.024	.021	.024
3	.028	.031	.035	.027	.033	.024	.024	.029
5	.035	.037	.035	.033	.034	.034	.035	.035
7	.038	.039	.037	.038	.046	.030	.080	.037
TOWER 3.								
1	.014	.016	.021	.020	.014	.018	.014	.017
3	.024	.024	.025	.024	.022	.022	.022	.024
5	.034	.033	.033	.033	.035	.028	.036	.033
7	.038	.034	.037	.032	.038	.031	.047	.037
TOWER 4.								
1	.025	.024	.024	.024	.024	.024	.025	.024
3	.031	.031	.032	.031	.031	.020	.030	.031
5	.035	.039	.038	.033	.036	.037	.036	.036
7	.038	.040	.038	.037	.040	.043	.039	.039
TOWER 5.								
1	.028	.036	.030	.021	.020	.020	.022	.025
3	.034	.044	.037	.031	.036	.035	.033	.086
5	.036	.045	.044	.037	.041	.038	.035	.039
7	.040	.043	.041	.039	.042	.043	.041	.041

The values of the temperature are taken from the curve for the twenty-four hours at the mean value for the intervals given, to conform to the integration, and practically it is taken for the time at the mean of the interval. They can be found approximately on Table 9. E_1 is taken at the end of the interval on the curve, as drawn thru the observations; de/dS is taken from Table 15. Similar computations for pans 1, 3, 5, and 7, on towers 1, 2, 3, 4, and 5, are collected in Table 17.

TABLE 18.—*Computation of the wind constant A.*

$$A=\frac{E_2-E_1}{E_1\,w_2}=\frac{E_3-E_1}{E_1\,w_3}.$$

Pans.		8 p. m.–1 a. m.	1–5 a. m.	5–8 a. m.	8–11 a. m.	11 a. m.–2 p. m.	2–5 p. m.	5–8 p. m.	Means
TOWER 1.									
1	w_2 ..	0.018	0.023	0.021	0.017	0.015	0.015	0.022	0.019
	w_3 ..	.023	.037	.024	.024	.020	.021	.020	.024
3	w_2 ..	.020	.024	.018	.015	.011	.016	.018	.017
	w_3 ..	.022	.017	.024	.018	.016	.019	.019	.019
5	w_2 ..	.021	.019	.012	.013	.012	.015	.013	.015
	w_3 ..	.021	.021	.018	.014	.013	.016	.015	.017
7	w_2 ..	.014	.016	.018	.011	.009	.014	.013	.014
	w_3 ..	.016	.017	.020	.014	.010	.013	.017	.015
TOWER 2.									
1	w_2 ..	.016	.022	.022	.024	.020	.011	.012	.018
	w_3 ..	.020	.026	022	.028	.021	.015	.012	.021
3	w_2 ..	.019	.027	.023	.020	.014	.010	.009	.017
	w_3 ..	.022	.026	.028	.027	.019	.014	.015	.022
5	w_2 ..	.011	.020	.022	.020	.015	.009	.007	.015
	w_3 ..	.013	.024	.031	.025	.018	.014	.018	.020
7	w_2 ..	.017	.028	.022	.015	.013	.012	.011	.017
	w_3 ..	.017	.029	.026	.020	.018	.017	.012	.020
TOWER 3.									
1	w_2 ..	.015	.015	.021	.025	.028	.019	.015	.020
	w_3 ..	.018	.019	.030	.031	.034	.022	.019	.025
3	w_2 ..	.010	.014	.012	.012	.012	.011	.011	.012
	w_3 ..	.012	.014	.018	.019	.015	.014	.015	.015
5	w_2 ..	.012	.020	.318	.020	.020	.019	.013	.017
	w_3 ..	.016	.022	.024	.025	.024	.022	.015	.021
7	w_2 ..	.014	.018	.013	.010	.013	.016	.011	.014
	w_3 ..	.016	.020	.015	.014	.017	.016	.013	.016
TOWER 4.									
1	w_2 ..	.010	.019	.023	.016	.009	.009	.012	.014
	w_3 ..	.012	.024	.027	.019	.013	.011	.013	.017
3	w_2 ..	.016	.018	.018	.016	.015	.014	.010	.015
	w_3 ..	.019	.022	.024	.022	.018	.016	.012	.019
5	w_2 ..	.014	.015	.014	.015	.014	.014	.011	.014
	w_3 ..	.016	.018	.019	.021	.018	.019	.012	.018
7	w_2 ..	.015	.016	.015	.011	.015	.016	.013	.014
	w_3 ..	.016	.016	.018	.019	.019	.018	.015	.017
TOWER 5.									
1	w_2 ..	.012	.013	.015	.020	.019	.014	.013	.015
	w_3 ..	.015	.019	.025	.027	.024	.018	.016	.021
3	w_2 ..	.013	.016	.017	.018	.012	.012	.017	.015
	w_3 ..	.014	.015	.021	.021	.014	.013	.017	.016
5	w_2 ..	.014	.020	.017	.018	.011	.015	.013	.015
	w_3 ..	.017	.021	.022	.018	.013	.016	.015	.017
7	w_2 ..	.014	.026	.025	.014	.012	.013	.011	.016
	w_3 ..	.014	.022	.023	.017	.013	.014	.013	.017

Mean A-constant, Tower 1,	0.0175
2,	.0188
3,	.0175
4,	.0160
5,	.0165
Mean	.0173
Adopted A-constant	0.0175

With this value of the A-constant, and the mean values of the C-function given in Table 17, the values of E_1, E_2, E_3, which appear in Tables 9–13 and in figs. 23–27, were computed for the 4 pans on the 5 towers.

THE DIFFUSION COEFFICIENT $Cf(h)$.

I will call the variable term C the diffusion coefficient till the complete elucidation of the function shall suggest a better name. In order to bring out some of its characteristics, the values of C obtained for the pans on the several towers will be plotted on fig. 29. The depression of the curves in the middle of the reservoir, and the progressive spacing between them, suggests that they are arranged on a geometric ratio, counting the distances from a *maximum* line C_0 to be determined by computation. The fall of the line C_4 at tower No. 5 corresponding with the lowest pan in the alfalfa field is due to the irrigation of the ground, which makes the lower stratum act like the water of the reservoir to some extent. The dotted line eliminates that feature. By a few trials I have determined the C_0 line which conforms with this theory, as follows:

TABLE 19.—*The geometrical ratio* $\rho=\varpi_{n+1}/\varpi_n$.

Towers.	5	ϖ_n	4	ϖ_n	3	ϖ_n	2	ϖ_n	1	ϖ_n
C_0	.044		.044		.043		.042		.041	
		3		5		6		5		4
C_1	.041		.039		.037		.037		.037	
		5		8		11		7		6
C_2	.039		.036		.032		.035		.035	
		8		13		18		13		9
C_3	.036		.031		.025		.029		.032	
		18		20		26		18		11
C_4	.031		.024		.017		.024		.030	
Ratio $\frac{\varpi_{n+1}}{\varpi_n}$		1.67 1.60 1.63		1.60 1.63 1.54		1.83 1.64 1.44		1.40 1.86 1.39		1.50 1.50 1.22
Mean ρ		1.63		1.59		1.64		1.55		1.41

$$\text{Mean}\ \frac{\varpi_{n+1}}{\varpi_n}=\rho=1.55.$$

Assume the line C_0 and take successive differences between C_0 and the lower curves C_0-C_1, C_0-C_2, C_0-C_3, C_0-C_4, C_0-C_5. Divide these differences in succession

$$\rho=\frac{\varpi_{n+1}}{\varpi_n}=\frac{\varpi_2}{\varpi_1}=\frac{\varpi_3}{\varpi_2}=\frac{\varpi_4}{\varpi_5}=1.55. \tag{39}$$

Assume coordinate values for the lower line C_4, and take an assigned value for C_0; subtract C_4 from C_0 to obtain C_0-C_4, and then divide by 1.55 in succession to adjust the assumed C_0.

TABLE 20.—*Adjustment of the C-function to the geometrical law.*

COMPUTATION OF THE ADJUSTED ΔC.

Symbol.	C	ΔC	C	ΔC	C	ΔC	C	ΔC	C	ΔC
C_0	.0430	.....	.0430	.....	.0430	.....	.0430	.....	.0430	.....
C_1	.....	.0032	.....	.0051	... .	.0070	.....	.0054	.....	.0038
C_2	....	.0050	.....	.0079	.....	.0108	.....	.0083	.....	.0058
C_3	.....	.0077	.....	.0123	.....	.0168	.....	.0129	.....	.0090
C_4	.0310	.0120	.0240	.0190	.0170	.0260	.0230	.0200	.0290	.0140

COMPUTATION OF THE ADJUSTED C.

Symbol.	C		C		C		C		C	
C_0	.0430	.....	.0430	.....	.0430	.....	.0430	.....	.0430	.....
C_1	.0398	.....	.0379	.....	.0360	.....	.0376	.....	.0392	.....
C_2	.0380	.....	.0351	.....	.0322	.....	.0347	.....	.0372	.....
C_3	.0353	.....	.0307	.....	.0262	.....	.0301	.....	.0340	.....
C_4	.0310	.....	.0240	.....	.0170	....	.0230	.....	.0290	.....

To compute the adjusted ΔC proceed as follows: Assume for C_0 the mean value .0430 for each tower, and for C_4 in succession .0310, .0240, .0170, .0230, .0290. Take the differences .0120, .0190, .0260, .0200, .0140, and divide in succession up the column by 1.55. Thus .0077=.0120/1.55, .0050=.0077/1.55, .0032=.0050/1.55. Then subtract ΔC from C_0 in succession for C_1, C_2, C_3, C_4. Fig. 30 contains the adjusted values of C and may be compared with fig. 29, which certainly suggests this geometrical law,

$$C_n=C_0-(C_0-C_1)\left(\frac{\varpi_{n+1}}{\varpi_n}\right)^n=C_0-\Delta C_1\,\rho^n. \tag{40}$$

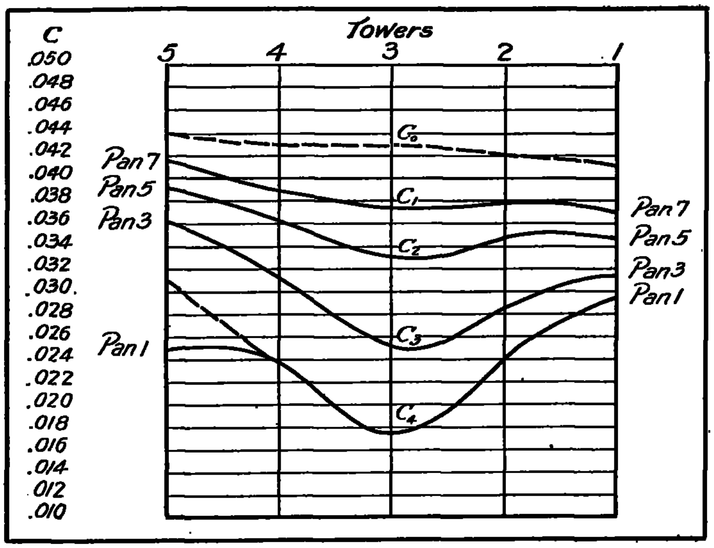

FIG. 29.—The C-coefficient as derived from the computations of the observations.

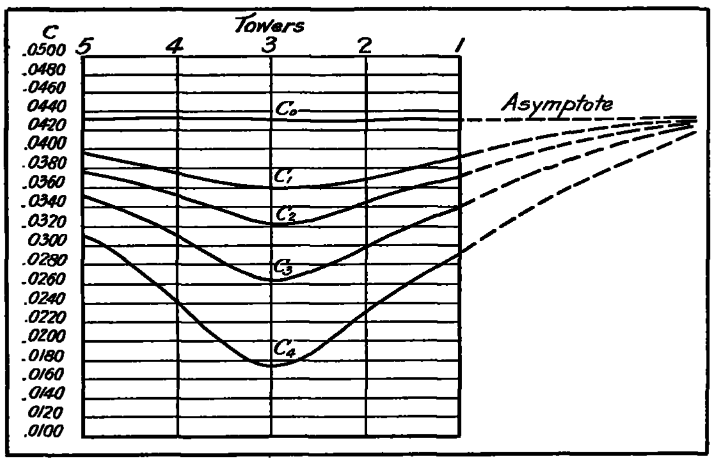

FIG. 30.—The C-coefficient adjusted by the law of a geometrical ratio.

It is, also, very desirable to extend the C-function to heights beyond the reach of observations on the towers, and it can apparently be readily done. The observations on the pans 1, 3, 5, and 7 were taken at the following approximate heights, the small variations having no influence on the amount of the evaporation, as stated in the preceding pages:

Pan 7, 12 meters, 39.4 feet.
Pan 5, 6 meters, 19.7 feet.
Pan 3, 3 meters, 9.8 feet.
Pan 1, 0 meters, 0.0 feet.

THE C-COEFFICIENT.

The coefficient C is a variable with the height, and there is evidence that it has a small diurnal and annual period at the same place. The further discussion of this term must be left for the campaign at the Salton Sea.

Now it follows that this series of heights can be represented by a simple formula,

(40) $$h_n = 3 \times 2^{n-2},$$

not counting the height of the first pan, since,

$h_2 = 3 \times 2^{2-2} = 3 \times 1 = 3$, for pan (3),
$h_3 = 3 \times 2^{3-2} = 3 \times 2 = 6$, for pan (5),
$h_4 = 3 \times 2^{4-2} = 3 \times 4 = 12$, for pan (7),
$h_5 = 3 \times 2^{5-2} = 3 \times 8 = 24$.

Hence, the heights can be controlled by a geometrical ratio law of which 2 is the factor. We, therefore, construct the reciprocal of the ρ-ratio, and take the log of $1/\rho$ for the height having the number 2, at which point this law begins to apply. Table 21 contains the computation. Take $\rho = 1.55$ find its logarithm and reciprocal, and subtract the log $1.55 = 0.19033$ in succession up to n times. Take the values of C_0 corresponding to a height $h = \infty$, which is to be the asymptote to the group of C curves in fig. 30; also, C at the height $h = 0$, on the water and land surfaces. Take the difference $\Delta C = C_0 - C$ and its logarithm. Add this in succession to the series of log $1/\rho$. The next section contains the corresponding numbers ΔC at the successive heights, and the last section the corresponding values of C_n, formed by subtracting ΔC_n from C_0 in succession. The four lines at the head of this table are identical with those in Table 20, the others constituting the extension required.

Plotting these values of C_n to the argument h_n on fig. 31, we have the structure of the C-function relative to the height. The maximum value of C is .0430, *which corresponds to a maximum evaporation outside the vapor blanket covering the reservoir*, and it is at some asymptotic distance, Practically the curves approach this value at about 40 meters = 131 feet, and this is the height at which the blanket fails to have any influence. The chief effect is within 60–70 feet of the surface. This method of computing the depth of a vapor blanket is of great practical value in studying these problems, as can be easily perceived, because it renders unnecessary the construction of lofty towers, since the initial values for the formula can be found within 40 feet of the surface.

TABLE 21.—*Extension of the C function to the heights* $h_n = 3 \times 2^{n-2}$.

I. COMPUTATION OF LOG $1/\rho$ FOR SUCCESSIVE POWERS OF 2.

Tower.		No. 5.	No. 4.	No. 3.	No. 2.	No. 1.	Height.
ρ				1.55			
log ρ		Same as No. 3.	Same as No. 3.	0.19033	Same as No. 3.	Same as No. 3.	$h_n = 3 \times 2^{n-2}$
log $1/\rho$	2			9.80967			
	3			9.61934			
	4			9.42901			
	5			9.23868			
	6			9.04835			
	7			8.85902			
	8			8.66769			
	9			8.47736			
	10			8.28703			

II. COMPUTATION OF LOG ΔC FOR SUCCESSIVE HEIGHTS.

C_0 at $h = \infty$		.0430	.0430	.0430	.0430	.0430	....
C at $h = 0$		.0310	.0240	.0170	.0230	.0290	....
ΔC		.0120	.0190	.0260	.0200	.0140	....
log ΔC_n	1	8.07918	8.27875	8.41497	8.30103	8.14613	0
	2	7.88885	8.08842	8.22464	8.11070	7.95580	$3 \times 2^0 = 3$
	3	7.69852	7.89809	8.03431	7.92037	7.76547	$3 \times 2^1 = 6$
	4	7.49819	7.70776	7.80498	7.73004	7.57514	$3 \times 2^2 = 12$
	5	7.30786	7.51743	7.65365	7.53971	7.38481	$3 \times 2^3 = 24$
	6	7.12753	7.32710	7.46332	7.34938	7.19448	$3 \times 2^4 = 48$
	7	6.93820	7.13777	7.27399	7.16005	7.00515	$3 \times 2^5 = 96$
	8	6.74687	6.94644	7.08266	6.96873	6.81382	$3 \times 2^6 = 192$
	9	6.55654	6.75611	6.89233	6.77839	6.62349	$3 \times 2^7 = 384$
	10	6.36621	6.56578	6.70200	6.58806	6.43316	$3 \times 2^8 = 768$

III. COMPUTATION OF ΔC FOR SUCCESSIVE HEIGHTS.

ΔC_n	1	.0120	.0190	.0260	.0200	.0140	0
	2	.0077	.0123	.0168	.0129	.0090	3
	3	.0050	.0079	.0108	.0083	.0058	6
	4	.0032	.0051	.0070	.0054	.0038	12
	5	.0020	.0033	.0045	.0035	.0024	24
	6	.0013	.0021	.0029	.0022	.0016	48
	7	.0009	.0014	.0019	.0014	.0010	96
	8	.0006	.0009	.0012	.0009	.0007	192
	9	.0004	.0006	.0008	.0006	.0004	384
	10	.0002	.0004	.0005	.0004	.0003	768

IV. COMPUTATION OF C FOR SUCCESSIVE HEIGHTS. $h_n = 3 \times 2^{n-2}$

C_n	1	.0310	.0240	.0170	.0230	.0290	0
	2	.0353	.0307	.0262	.0301	.0340	3
	3	.0380	.0351	.0322	.0347	.0372	6
	4	.0398	.0379	.0360	.0376	.0392	12
	5	.0410	.0397	.0385	.0395	.0406	24
	6	.0417	.0409	.0401	.0408	.0414	48
	7	.0421	.0416	.0411	.0416	.0420	96
	8	.0424	.0421	.0418	.0421	.0423	192
	9	.0426	.0424	.0422	.0424	.0426	384
	10	.0428	.0426	.0425	.0426	.0427	768

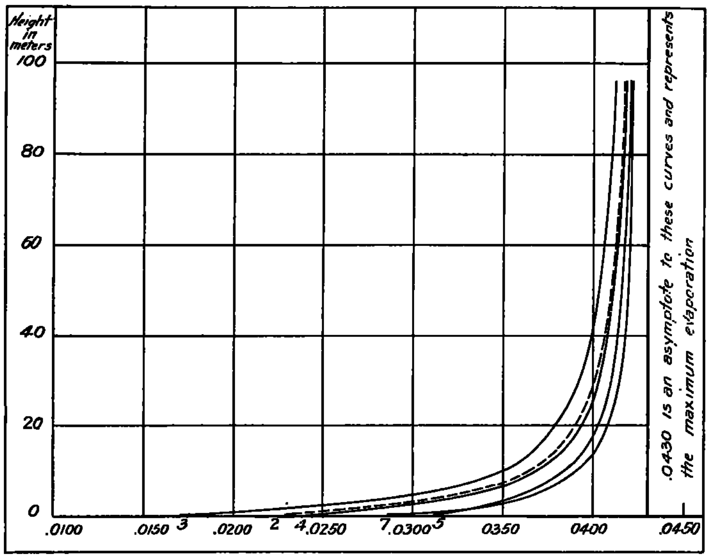

FIG. 31.—The curves of the *C*-coefficient for the several towers, showing the great variability in the lower layers of the atmosphere. The stations at Mammoth Tank and Edom are designed to give the value of the *C*-coefficient as a maximum, while the stations at Indio, Mecca, and Brawley will give values of *C* in the irrigated districts, and the towers in the Salton Sea will give values for water surfaces and the adjacent strata of the atmosphere. The relation of these coefficients to a broad water area which is evaporating must be studied before the integral of the loss of water over a sea, a lake, or a reservoir can be found. This is a problem of much difficulty to reduce to a simple practical form.

SUMMARY.

In reviewing the outcome of the Reno work I feel satisfied with the wind coefficient A, with the use of the coefficient de/dS, and with the fact that $Cf(h)$ has been shown to be a very complex variable. The introduction of the vapor pressure e in that formula is probably incomplete, and it may well be that the elucidation of the function C will give it a very different setting. It will be necessary to build three or four towers in the Salton Sea, and possibly one on a small island near the southern end of the lake; the stations at Edom, Indio, Mecca, Brawley, and Mammoth Tank will have observing stands to carry one pan 10 feet above the ground, while another pan is on the surface. The size of the pans makes an insignificant difference in the amount of evaporation, when they are under identical local conditions. We used six improved Piche evaporimeters at Reno, and compared them directly with the evaporation from the pans at the same elevations and under like conditions, with the hope of substituting these more sensitive instruments for the large pans. They consist of a volumetric tube about 30 cm. long carrying 40 scale divisions, the tube being 1.8 cm. in diameter. The glass was blown so that a small Mariotte tube, in communication with the free air, extended down the middle to within 1 cm. of the bottom. A circular glass plate 8 cm. in diameter was covered by a good filter paper and held against the bottom of the tube by a spring and screw. The water flows from the tube thru the filter paper and evaporates from the *upper* surface only, the air pressure being nearly constant on the inside by reason of the Mariotte tube admitting air to the upper part as the water falls. The area of the paper is 50.27 cm^2, and of the tube 2.54 cm^2, so that the water evaporates from 47.73 cm^2 of the paper. At Reno the evaporation was rapid enough to exhaust the water in about three hours in strong winds during the afternoon, so that the rate of the fall of the water was about 55 times greater in the tube than in the open pans, an advantage in accurate reading, *provided the ratio is a constant.* Table 22 shows that this ratio has a marked diurnal period. It is not probable that the measurements of the water-fall in the pans are seriously in error, and we must conclude that the action of the filter paper in conveying water to the edge and losing it by evaporation is variable. In high winds, 25 to 35 km. per hour, the edges of the paper dried out faster than the water could travel thru the paper from the feeding tube to the edge, 3 cm. distant, so that the paper often became detached from the glass plate in high winds. In the early morning hours the evaporation was not fast enough for the pans, and the fiber of the paper may have retained the vapor particles in a thin skin longer than the water surface in the pan under similar conditions. It was a disappointment to find that this promising piece of apparatus must receive further study and development.

TABLE 22.—*Ratio of evaporimeter to water-fall in pans.*

$$\text{Ratio} = \frac{\text{Fall of water in the evaporimeter tube}}{\text{Fall of water in the open pan.}}$$

Intervals.	1 a.m.	5 a.m.	8 a.m.	11 a.m.	2 p.m.	5 p.m.	8 p.m.	Day.
Evaporimeter No. 1:								
Aug. 5-10	71	51	41	75	48	51	44	54.4
12-17	62	47	12	35	48	58	56	45.4
Pans 1, 2. 19-24	79	41	14	48	63	46	68	51.3
26-31	60	26	15	41	89	61	53	49.3
Sept. 2-7	49	26	17	58	61	49	49	44.1
9-14	72	55	29	44	73	50	71	56.3
Means	65.5	41.0	21.3	50.2	63.7	52.5	56.8	50.1
Evaporimeter No. 2:								
Aug. 5-10	63	47	58	84	103	95	85	76.5
12-17	107	41	18	68	88	101	107	75.1
Pan 3. 19-24	109	47	24	64	58	74	69	63.6
26-31	68	23	19	64	82	63	65	54.9
Sept. 2-7	43	31	9	42	85	43	39	41.7
9-14	70	54	21	43	52	42	66	49.7
Means	76.7	40.5	24.8	60.2	78.0	69.7	71.8	60.3
Evaporimeter No. 3:								
Aug. 5-10	59	43	44	64	79	62	71	60.3
12-17	86	45	23	55	62	72	86	61.5
Pan 4. 19-24	95	59	34	74	67	58	91	68.3
26-31	89	59	46	61	72	67	81	67.9
Sept. 2-7	59	42	26	47	66	57	63	51.4
9-14	70	56	35	67	65	53	74	60.0
Means	75.4	50.7	34.7	61.3	68.5	61.5	77.7	61.6
Evaporimeter No. 4:								
Sept. 2-7	68	31	19	51	67	65	71	53.1
Pan 5. 9-14	53	54	37	54	78	71	73	60.0
Means	60.5	42.5	28.0	52.5	72.5	68.0	72.0	56.5
Evaporimeter No. 5:								
Sept. 2-7	77	33	29	48	71	64	64	55.1
Pan 6. 9-14	60	45	39	64	71	50	53	54.6
Means	68.5	39.0	34.0	56.0	71.0	57.0	58.5	54.9
Evaporimeter No. 6:								
Sept. 2-7	70	28	24	42	64	59	69	50.9
Pan 7. 9-14	77	43	38	58	64	53	64	56.7
Means	73.5	35.5	31.0	50.0	64.0	56.0	66.5	53.8
Means of all.	70.5	41.5	29.0	55.0	69.6	60.8	67.2	56.2

Since there is evaporation from 47.73 cm^2 of the paper and the mean ratio is 56.2 it follows that the evaporation averages 1.177 times faster from each cm^2 of paper to each cm^2 of the free water surface. It is possible that some method can be devised to serve more uniformly than the paper acting as a conductor of the water.

It is very important to devise self-registering apparatus, because the labor of three-hourly observations by personal work is such as to exclude evaporation from general study, except by rough summaries, as the total daily amounts, wherein the process is entirely obscured from analysis. These instruments should include a vapor pressure apparatus, and an evaporation apparatus, as well as a thermometer for the water surface, besides the common thermograph. As a practical matter, in order to save the great labor of three-hourly observations in default of self-registering apparatus, it is desirable to find a single three-hour observation of the evaporation which, multiplied by the factor 8, will be equivalent to that amount occurring in twenty-four hours. In Tables 9–13 is given the mean of the eight three-hourly amounts of the evaporation; multiply this by 8 for the total amount in twenty-four hours in centimeters, 1 cm=0.394 inch. Plotting this value on the curves of figs. 23–27 and noting the times of occurrence of this ordinate, it is found to average about 10:30 a. m. and 10 p. m. That is to say, if a measure of the height of the water in the pan be made at 7:30 a. m., and another at 10:30 a. m., the difference multiplied by 8 will be closely the total evaporation for the day. This rule holds at Reno, Nev., during the summer, but it should be verified in other localities. Furthermore, in the arid regions of the West it seems probable that a lake or reservoir evaporates about five-eighths as fast as an isolated pan placed outside the vapor blanket; in other words, this vapor blanket seems to conserve about three-eighths of the water that would otherwise be lost by the evaporation. It is important that similar experiments with towers be made in the central and eastern portions of the United States, in the prevailing damp climates, to discover whether similar rules can be applied in practise. A careful campaign on the theory of evaporation is evidently demanded to elucidate this complex function of the evaporation of water in the open air, and it is probable that several years will be required in order to bring it to a satisfactory conclusion.

THE WEATHER OF THE MONTH.

By Mr. P. C. DAY, Assistant Chief, Division of Meteorological Records.

PRESSURE.

The distribution of mean atmospheric pressure for February, 1908, over the United States and Canada, is graphically shown on Chart VI, and the average values and departures from the normal are shown for each station in Tables I and III.

February mean pressure partook generally of the usual winter type, a ridge of high pressure, 30.10 to 30.15 inches, stretching from the east Florida coast northwestward to the upper Missouri Valley and thence southwesterly to the middle Pacific coast, diminishing gently to about 30.00 inches over the Canadian Maritime Provinces, the southern portions of Arizona and New Mexico, and over northwest Washington and British Columbia.

There was a decided increase in pressure from that of January, 1908, over the districts east of the Rocky Mountains, while over the Plateau districts a compensating decrease occurred.

Pressure averaged above the normal over practically all districts of the United States and Canada, except over the Pacific coast and the central Mississippi Valley.

The building up of the area of high pressure over the upper Missouri Valley and generally along the northern border brought nearly all districts east of the Missouri and Mississippi valleys under the influence of westerly and northwesterly surface winds, and over the northern tier of States from North Dakota eastward, including the Lake region, New England, and the north Atlantic coast, the month was unusually stormy, the average wind velocity at many points exceeding the normal from 30 to 50 per cent.

The extension of the south Atlantic high area westward over Texas and the Southwest gave southerly winds from the lower Mississippi Valley westward over Texas, and generally over the region from the Rocky Mountains to the Pacific. Over these districts storms were remarkably infrequent and the monthly wind movement was correspondingly less than the average.

TEMPERATURE.

The average temperature remained above the normal, as during the preceding months since October, inclusive, over most of the districts west of the Mississippi Valley, only a small area over the lower Colorado Valley and the central and south Pacific coasts showing temperatures slightly below the average.

Over the entire Missouri Valley and northern slope and Plateau districts the average temperature ranged from 4° to 8° above the normal, and across the border in the Canadian Northwest Provinces unusually mild weather was the rule thruout the month.

From the Missouri Valley westward to the Pacific and southward over most of the Great Plains, mountain, and Plateau districts the mean temperature has remained above the normal during the past five months, and the accumulated excess during that period ranges from about 2° daily in the more southern portions to more than 7° daily over portions of Montana and the Dakotas.

Over the districts east of the Mississippi the average temperature was generally below the normal, the deficiency ranging from 3° to 5° daily over the Appalachian Mountain region, east Gulf States, and the Florida Peninsula.

During the first few days of the month a cold wave of considerable severity prevailed over the northern Rocky Mountain and Plateau districts, extending into the Great Plains and central valleys, but aside from the above no extended or severe periods of cold occurred over those districts.

The continuous discharge of cold winds from the Hudson Bay region over the lower Lakes and New England gave to those districts frequent and severe periods of cold.

Over the northern portions of New York and New England minimum temperatures from 30° to 40° below zero were recorded, the lowest reported in those districts for many years.

Temperatures as low as −40° were recorded also over the mountain districts of southeastern Idaho and northwestern Wyoming on the 1st and 2d, but these readings were probably due to the intense nocturnal radiation possible in the clear, dry atmosphere of that region, rather than to the intensity of the advancing cold area.

Altho temperatures were moderate over most of the northern districts, several periods of cold weather, for the latitude, penetrated into the Gulf and south Atlantic coast districts, and freezing temperatures with killing frosts occurred on numerous dates, extending to the immediate coast line and to the interior districts of central Florida.

PRECIPITATION.

The distribution of precipitation during February, 1908, is graphically shown on Chart IV by appropriate shading or by figures representing the actual amount of fall over districts the topography of which is too varied to admit of approximately correct shading.

The precipitation over the lower Ohio and middle Mississippi valleys was comparatively heavy, ranging from 6 to 10 inches; over the remaining districts east of the Mississippi River the amounts were very generally from 2 to 4 inches, except over southern Florida, where the fall averaged but slightly above 1 inch.

From the Missouri Valley and Great Plains westward over the Rocky Mountain and Plateau districts the amount of fall was generally less than 1 inch, except over portions of Arizona and New Mexico, where amounts from 2 to 6 inches were recorded.

Comparatively heavy precipitation, from 5 to 10 inches, occurred over the mountains near the coast of California, Oregon, and Washington, and also over the high elevations of the Sierra and Cascade ranges in those States.

Along the immediate Atlantic coast from New England to Florida, over the Appalachian district from Maryland southward, and the east Gulf States, there was a general deficiency in precipitation ranging from 1 inch to 3 inches.